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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

# RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 3 March 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

*Radiological Health Data and Reports*, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● Division of Radiological Health

# Reports

## VARIABILITY OF FLUID MILK CONSUMPTION AND ITS RELATIONSHIP TO RADIONUCLIDE INTAKE[1]

*J. C. Thompson, Jr.*[2]

SYNOPSIS—Using Federal milk marketing order statistics and population estimates for market areas, average monthly fluid milk consumption estimates were derived for cities located in areas covered by the Public Health Service Pasteurized Milk Network. The average per capita milk consumption for 67 cities in July 1962 was found to be 0.302 liters per day, which compared well with the Bureau of the Census estimate of 0.297 liters per day for the same month. Establishment of a comparative milk consumption—radionuclide level network is described for the 38 cities which participate in both collection of the milk order statistics and the PHS milk monitoring system. This method is useful for determining regional and temporal variations in average milk consumption. Widespread geographic variations in radionuclide intakes are apparent from a summary of data for these cities, ranging to as high as sixfold for strontium–90 and fifteenfold for cesium–137 between stations. The estimates indicate that the average intake of strontium–90 and cesium–137 are approximately 70 percent less than estimates based on an assumed milk consumption of 1 liter per day. It is emphasized, however, that the averages include portions of the population whose milk intake is considerably greater than the average. These represent the critical elements in public health planning if large releases of radioactivity should occur.

The worldwide levels of environmental radioactivity observed following atmospheric nuclear tests conducted by the United States and U.S.S.R. in 1961–1962 emphasized the importance of improving our methods of estimating radionuclide intake. This was particularly true for the actions taken by some States in attempting to reduce iodine–131 intake levels. These actions were based on iodine–131 intake estimates derived from measured iodine–131 levels in milk and arbitrary milk consumption data. None of the actions taken were recommended by Federal authorities. However, the fact that they were initiated points out the necessity for establishing a better understanding of the interrelationships that exist between milk consumption, iodine–131 intake, and thyroid uptake. These relationships are very important in determining any hazard from fallout iodine–131 radioactivity. They can also assist in evaluating the hazards from other major radionuclides found in milk, since it forms an important part of the diet.

The urgency of the measures taken by individual States was primarily related to the inherent characteristics of iodine–131; it is produced in large amounts during a nuclear detonation, efficiently secreted into edible food products, and is concentrated in a small gland (thyroid). Because of its short radioactive half-life (8 days), iodine–131 has special importance in food products that spend short-time periods in marketing channels. Thus, fresh whole milk was the most important food product of concern, because most other foods normally spend sufficient time in marketing channels to significantly decrease or eliminate iodine–131 levels by radioactive decay. Homegrown or locally produced vegetables might enter into consideration for certain population categories, but the quantities of iodine–131

[1] This work was partially supported by the U.S. Atomic Energy Commission.

[2] Dr. Thompson is assistant professor of the Department of Physical Biology, New York State Veterinary College (a contract college of the State University), Cornell University, Ithaca, New York.

available from these sources would be small (*1*). Standard home preparation practices (washing, peeling, etc.) would generally minimize the intake from these sources.

In order to properly assess the intake of iodine–131 or any radionuclide from milk, it is necessary to have accurate data on milk consumption. In the past, the practice has been to base estimates on an assumed milk consumption rate of 1 liter per person per day. However, this practice can lead to considerable error among various regions and locations and may contribute to public uncertainty and alarm during nuclear testing periods such as those of 1961 and 1962. If radionuclide intake levels are used as criteria for determining whether countermeasures are deemed advisable, then accurate consumption data are essential for this determination. Accurate milk consumption data can also assist in determining total radionuclide intake, since there is a correlation between total diet intake and the contribution from milk.

It is possible to obtain considerable data on fluid milk, since it is one of the few products that are extensively controlled throughout the United States, both at Federal and State levels. These controls range from sanitary codes to pricing regulations at producer, distributor, and retail levels. Such controls make it possible to obtain more meaningful and accurate data than are available for most other foods. Most of the data that are relevant for determining milk consumption are derived from Federal milk marketing order statistics which report sales of various milk products by specific marketing areas (*2*). Jurisdiction over milk sales on a regional basis is under Federal supervision and control in the 80 markets having Federal milk marketing orders. These orders are supervised by a market administrator appointed by the Secretary of Agriculture. Milk handlers are regulated under the provisions of such an order in the following manner:

(a) They must pay the minimum farm price as established by the Market Administrator's Office.

(b) They must make accurate weights and tests.

(c) They must properly account for the way in which the milk is used (quantities of milk received and sales in each product category).

These regulations are supplemented by the various Federal and State sanitary codes which often include reports on sales and disposition of fluid milk products.

Federal milk marketing order statistics report total monthly fluid milk sales in the area designated by the marketing order. Sales reports are filed for each Federal order area on a weight basis for sales within the area and verify the use which handlers have made of milk purchases from producers (sales by product category, type of container, etc.). All out-of-market sales are deleted from reported figures. Thus, except for losses in the store or home (spoiling, spilling, etc.) the data are indicative of the milk consumed in each market area.

Population estimates for each market area are updated annually by using information derived from census data and trends, population projections and estimates from State planning and development boards, business research, and other statistical services. These estimates consider only the persons living within the established boundaries of each Federal milk marketing order area.

Since 1962 the quantity of milk handled by all Federal marketing orders has represented about half of the milk delivered to all plants and dealers in the United States. However, within each individual market order area the data account for *all* of the sales made in the area. These sales data are subdivided according to the uses or products manufactured as required in a classified milk pricing program. Fluid milk sales data can then be extracted and related to the population data for each area to obtain the desired consumption estimates. Table 1 shows the average monthly fluid milk consumption in 1964 for the cities from the Federal milk marketing order network which are also located in areas covered by the Public Health Service Pasteurized Milk Network.

These data can be compared with fluid milk consumption estimates derived from the Bureau of the Census — Public Health Service study conducted in July 1962 (*4, 5*). The average per capita milk consumption from this study was 0.297 liters per day (weighted aver-

**Table 1. Average monthly per capita fluid milk consumption during 1964 in 38 major U.S. milksheds (3)**

| Major city in milkshed | Liters per month | Major city in milkshed | Liters per month |
|---|---|---|---|
| Albuquerque, N.M. | 7.9 | Memphis, Tenn. | 7.7 |
| Austin, Tex. | 8.3 | Milwaukee, Wis. | 9.2 |
| Baltimore, Md. | 7.6 | Minneapolis, Minn. | 10.8 |
| Boston, Mass. | 11.5 | New Orleans, La. | 7.6 |
| Buffalo, N.Y. | 9.8 | New York, N.Y. | 11.3 |
| Charlotte, N.C. | 6.0 | Oklahoma City, Okla. | 10.0 |
| Chattanooga, Tenn. | 9.7 | Omaha, Nebr. | 9.0 |
| Chicago, Ill. | 9.7 | Philadelphia, Pa. | 9.1 |
| Cincinnati, Ohio | 8.8 | Phoenix, Ariz. | 8.3 |
| Cleveland, Ohio | 10.5 | Providence, R.I. | 11.8 |
| Dallas, Tex. | 8.6 | Rapid City, S.D. | 9.8 |
| Denver, Colo. | 8.3 | St. Louis, Mo. | 8.0 |
| Des Moines, Iowa | 9.3 | Salt Lake City, Utah | 7.8 |
| Detroit, Mich. | 10.8 | San Francisco, Calif. | 9.2 |
| Hartford, Conn. | 11.0 | Seattle, Wash. | 8.4 |
| Indianapolis, Ind. | 9.5 | Spokane, Wash. | 6.3 |
| Kansas City, Mo. | 8.9 | Washington, D.C. | 9.0 |
| Little Rock, Ark. | 6.4 | Wichita, Kans. | 8.6 |
| Louisville, Ky. | 8.7 | Wilmington, Del. | 9.1 |
| | | Average | 9.0 |

age using all age groups and both sexes) for the month of July 1962. This compares with an average of 0.302 liters/day from the 67 Federal milk market order stations operating during the same month. The close agreement of results indicates the similarity between the estimating procedures. Since the Federal milk marketing program offers the advantage of more recent information, its use would be advantageous in any appraisal of radionuclide intake. In addition, it would permit an evaluation of regional as well as individual market variations on an annual or seasonal basis. Some of these differences are shown in table 2 for the markets which are included in the Public Health Service Pasteurized Milk Network. The pattern of consumption is generally consistent from year to year with small changes in seasonal or annual totals.

**Table 2. Fluid milk consumption by geographic regions of the United States; 38 markets located within PHS Pasteurized Milk Network, 1964**

| Month | Milk consumption, liters/capita per month | | | | |
|---|---|---|---|---|---|
| | Northeast | North Central | South | West | Average |
| January | 11.1 | 10.0 | 8.5 | 8.5 | 9.4 |
| February | 11.0 | 10.0 | 8.5 | 8.5 | 9.4 |
| March | 10.8 | 9.6 | 8.2 | 8.1 | 9.1 |
| April | 10.9 | 9.7 | 8.3 | 8.3 | 9.2 |
| May | 10.6 | 9.1 | 7.9 | 7.9 | 8.7 |
| June | 10.5 | 8.7 | 7.6 | 7.5 | 8.4 |
| July | 10.2 | 8.6 | 7.6 | 7.3 | 8.3 |
| August | 10.2 | 8.7 | 7.6 | 7.4 | 8.3 |
| September | 11.0 | 9.8 | 8.7 | 8.3 | 9.3 |
| October | 11.3 | 10.2 | 9.0 | 8.6 | 9.7 |
| November | 10.8 | 9.6 | 8.5 | 8.1 | 9.1 |
| December | 10.8 | 9.5 | 8.2 | 8.0 | 9.0 |
| Average | 10.8 | 9.4 | 8.2 | 8.0 | 9.0 |

Seasonal changes generally involve a summer decline which can be related to such factors as temperature and the number of children out of school. Normal consumption levels are resumed when schools reopen and, except for a small holiday decline, are maintained until the following summer.

Variation in milk consumption by age and sex is another important consideration and was also cited in the Bureau of the Census — Public Health Service study. Some of the more pertinent points were the higher consumption rate for male persons (37 percent greater than female), the similarity of consumption patterns up to the late teens, and the lack of any group having average daily consumption levels over 0.6 liters. These data are in agreement with consumption information from a similar study conducted in Canada during the spring of 1963 (*6*). However, the Canadian study reported a very low daily intake estimate for babies younger than 6 months of age (average daily consumption was 0.47 liters). Other points, such as much higher consumption for rural farm areas, were also in agreement with previous U.S. data (*7*).

By incorporating all of the available data for an individual market it becomes possible to derive estimates of radionuclide intake from milk for different components of the population. The Boston area is used to illustrate this approach:

The July 1962 average fluid milk consumption for the Boston area (Federal milk market statistics) was 0.353 liters per person per day. This compares with the average of 0.297 liters per day for the Bureau of the Census — Public Health Service study. Therefore, Boston consumption was 18.8 percent higher than the average of 38 milksheds and this figure could serve as a weighting factor for determining differences in consumption due to age and sex (table 3).

This procedure would then give a good estimate of the milk consumed by the population of the Boston area. It could then be used with radionuclide concentration data from this milkshed to establish intake by each segment of the population. Prediction studies and hazard estimates could then be made and correlated to observed levels whenever deter-

mined by bone analyses, whole body counts, or thyroid monitoring.

**Table 3. Example of adjusted milk consumption by age group for specific area (Boston, Massachusetts), July 1962**

| Age | Daily per capita milk consumption (liters/day) | | | |
|---|---|---|---|---|
| | Census—PHS study | | Adjusted consumption * | |
| | Male | Female | Male | Female |
| Under 1 | .527 | .479 | .626 | .569 |
| 1–4 | .530 | .503 | .630 | .598 |
| 5–9 | .479 | .447 | .569 | .531 |
| 10–14 | .510 | .382 | .606 | .454 |
| 15–19 | .510 | .293 | .606 | .348 |
| 20–24 | .352 | .213 | .418 | .253 |
| 25–29 | .293 | .192 | .348 | .228 |
| 30–34 | .263 | .166 | .312 | .197 |
| 35–44 | .243 | .160 | .289 | .190 |
| 45–54 | .228 | .154 | .271 | .183 |
| 55–64 | .240 | .169 | .285 | .201 |
| 65+ | .246 | .192 | .292 | .228 |
| All ages | .346 | .251 | .411 | .298 |

* Using weighting factor of 1.188

The assumption of a population composition similar to the U.S. distribution insofar as numbers of male and female persons in respective age groups would be required in this analysis. This is a reasonable assumption for the larger market areas which are in the Federal milk market network. Using this approach would permit an appraisal of monthly, geographic, age, and sex related variations in fluid milk consumption. More recently, monthly or annual estimates could be calculated in the same manner.

Applications of this method are particularly suited to estimates of radionuclide intake from milk. Information on the variables influencing milk consumption is more readily available than on most other foods because of the reporting systems and controls that are employed. This is also true for radionuclide data since the sampling of milk for radionuclide determination is a regular feature of the monitoring networks. Thus, it is possible to establish a comparative milk consumption-radionuclide level network for the 38 cities that collect Federal (or State) milk order statistics and are a part of the Public Health Service milk monitoring system (*8*). Results from this compilation permit a better evaluation of the radionuclide intake from milk throughout the country. When these data are summarized, widespread geographic variations become apparent (table 4).

In general, the ranking by area follows the pattern indicated (Northeast, North Central, South, and West, in descending order). Individual variations between stations for a given year and area extend from two- to sixfold for strontium–90 and from two- to fifteenfold for cesium–137. With an awareness of this variation in one food item, it is easy to see how single dietary estimates can be extremely inaccurate.

Wide variations may also occur in estimating the milk component of total diets. Previous total diet studies (excluding infant diets) have shown the contribution of milk to total radionuclide intake to vary from 70 to 100 percent for iodine–131 (*1*), 10 to 90 percent for strontium–90, and 10 to 90 percent for cesium–137 (*9, 10*). The presence of such widespread variations would indicate that an analysis of each market and its component population is necessary so that individual factors can be considered.

The use of monthly milk consumption data, as developed here, in conjunction with radionuclide data will provide more accurate regional and market estimates of radionuclide intake from milk. This is shown in tables 5 and 6 where strontium–90 and cesium–137 intake

**Table 4. Comparison of strontium-90 and cesium-137 intake from milk by geographic area, 38 major milk markets of the United States, 1961–1964**

| Area | pCi strontium-90/capita • year | | | | pCi cesium-137/capita • year | | | |
|---|---|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1961 | 1962 | 1963 | 1964 |
| Northeast | 1,220 | 1,662 | 3,283 | 3,006 | 1,966 | 6,989 | 20,894 | 19,208 |
| North Central | 1,058 | 1,433 | 2,676 | 2,661 | 1,037 | 4,285 | 11,347 | 11,269 |
| South | 917 | 1,757 | 2,623 | 2,739 | 800 | 4,179 | 9,744 | 8,509 |
| West | 771 | 902 | 1,654 | 1,663 | 1,021 | 3,831 | 9,462 | 8,813 |
| 38-market average | 986 | 1,500 | 2,626 | 2,556 | 1,104 | 4,622 | 12,413 | 11,201 |

**Table 5. Estimated annual average per capita strontium-90 intake from milk in 38 market areas of the United States in 1964; comparison of intake levels based on assumed and actual milk consumption rates**

| Market area | Annual intake (picocuries) | | Market area | Annual intake (picocuries) | |
|---|---|---|---|---|---|
| | Assumed [a] | Actual [b] | | Assumed [a] | Actual [b] |
| Albuquerque, N.M. | 4,015 | 1,060 | Memphis, Tenn. | 11,680 | 2,910 |
| Austin, Tex. | 3,285 | 845 | Milwaukee, Wis. | 6,205 | 1,885 |
| Baltimore, Md. | 8,030 | 1,975 | Minneapolis, Minn. | 11,315 | 3,995 |
| Boston, Mass. | 11,315 | 4,235 | New Orleans, La. | 18,250 | 4,595 |
| Buffalo, N.Y. | 7,300 | 2,305 | New York, N.Y. | 9,125 | 3,365 |
| Charlotte, N.C. | 13,140 | 2,575 | Oklahoma City, Okla. | 8,030 | 2,670 |
| Chattanooga, Tenn. | 14,600 | 4,610 | Omaha, Nebr. | 9,125 | 2,605 |
| Chicago, Ill. | 6,935 | 2,170 | Philadelphia, Pa. | 7,300 | 2,250 |
| Cincinnati, Ohio | 8,030 | 2,310 | Phoenix, Ariz. | 1,460 | 450 |
| Cleveland, Ohio | 7,665 | 2,615 | Providence, R.I. | 8,395 | 3,270 |
| Dallas, Tex. | 6,935 | 1,955 | Rapid City, S. Dak. | 14,235 | 4,580 |
| Denver, Colo. | 6,935 | 1,935 | St. Louis, Mo. | 8,030 | 2,135 |
| Des Moines, Iowa | 9,125 | 2,725 | Salt Lake City, Utah | 9,125 | 2,400 |
| Detroit, Mich. | 6,570 | 2,320 | San Francisco, Calif. | 3,650 | 1,080 |
| Hartford, Conn. | 7,300 | 2,615 | Seattle, Wash. | 9,490 | 2,635 |
| Indianapolis, Ind. | 7,300 | 2,255 | Spokane, Wash. | 10,220 | 2,075 |
| Kansas City, Mo. | 9,855 | 2,825 | Washington, D.C. | 6,935 | 2,045 |
| Little Rock, Ark. | 15,695 | 3,255 | Wichita, Kans. | 7,665 | 2,170 |
| Louisville, Ky. | 10,950 | 3,070 | Wilmington, Del. | 8,030 | 2,355 |
| | | | Average | 8,770 | 2,560 |

[a] Strontium-90 intake from assumed consumption rate is based on 1 liter/day.
[b] Strontium-90 intake from actual consumption rate is based on data from Federal milk marketing statistics.

**Table 6. Estimated annual average per capita cesium-137 intake from milk in 38 market areas of the United States in 1964; comparison of intake levels based on assumed and actual milk consumption rates**

| Market area | Annual intake | | Market area | Annual intake | |
|---|---|---|---|---|---|
| | Assumed [a] | Actual [b] | | Assumed [a] | Actual [b] |
| Albuquerque, N.M. | 19,345 | 5,095 | Memphis, Tenn. | 24,820 | 6,220 |
| Austin, Tex. | 13,870 | 3,730 | Milwaukee, Wis. | 43,800 | 13,260 |
| Baltimore, Md. | 32,850 | 8,115 | Minneapolis, Minn. | 49,275 | 17,560 |
| Boston, Mass. | 74,095 | 28,160 | New Orleans, La. | 49,275 | 12,295 |
| Buffalo, N.Y. | 47,815 | 15,485 | New York, N.Y. | 53,290 | 19,925 |
| Charlotte, N.C. | 38,325 | 6,985 | Oklahoma City, Okla. | 23,725 | 7,865 |
| Chattanooga, Tenn. | 40,515 | 12,820 | Omaha, Nebr. | 31,755 | 8,780 |
| Chicago, Ill. | 39,785 | 12,700 | Philadelphia, Pa. | 40,150 | 12,415 |
| Cincinnati, Ohio | 31,390 | 9,185 | Phoenix, Ariz. | 9,125 | 2,480 |
| Cleveland, Ohio | 39,055 | 13,655 | Providence, R.I. | 54,750 | 21,140 |
| Dallas, Tex. | 21,170 | 5,895 | Rapid City, S. Dak. | 51,830 | 16,745 |
| Denver, Colo. | 32,120 | 8,690 | St. Louis, Mo. | 27,010 | 7,175 |
| Des Moines, Iowa | 30,295 | 9,260 | Salt Lake City, Utah | 60,225 | 15,400 |
| Detroit, Mich. | 38,325 | 13,555 | San Francisco, Calif. | 17,520 | 5,240 |
| Hartford, Conn. | 49,275 | 18,125 | Seattle, Wash. | 52,560 | 14,795 |
| Indianapolis, Ind. | 33,215 | 10,375 | Spokane, Wash. | 48,180 | 9,940 |
| Kansas City, Mo. | 26,695 | 7,870 | Washington, D.C. | 28,835 | 8,515 |
| Little Rock, Ark. | 42,705 | 8,765 | Wichita, Kans. | 22,995 | 6,470 |
| Louisville, Ky. | 29,565 | 8,560 | Wilmington, Del. | 41,245 | 12,360 |
| | | | Average | 37,110 | 11,200 |

[a] Cesium-137 intake from assumed consumption rate is based on 1 liter/day.
[b] Cesium-137 intake from actual consumption rate is based on data from Federal milk marketing statistics.

from milk are compared under an assumed consumption rate of 1 liter per day with actual consumption data from Federal milk market statistics. Estimates of strontium–90 and cesium–137 intake from milk derived from Federal milk market statistics are approximately 70 percent less than estimates based on an assumed consumption rate of 1 liter per day.

It may be noted that these estimates are consistent with average consumption data both from the Bureau of the Census—Public Health Service study and those of the Federal milk marketing program. The averages, however, include about 10 percent of the population who consume 1 liter or more of milk daily, as well as a substantial proportion (about one-third) who consume little or no milk (*4*, *5*). Consequently, an assumed consumption rate of 1 liter a day would constitute a conservative basis for consideration of any emergency action if large releases of radioactivity should occur. Information on radionuclide levels and regional consumption using available Federal milk marketing data would help to locate the most

vulnerable geographic area and, through adjustments similar to those shown in table 3, would provide an indication of intake by various age groups within individual markets.

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# CESIUM-137 IN FOOD—A SUMMARY OF RESULTS ON SELECTED FOODS IN THE UNITED STATES, JULY 1962 TO OCTOBER 1963

*Lloyd R. Setter, Donald Smith, and Mozart Spector*[1]

SYNOPSIS—Cesium–137 content and cesium–137 to potassium ratios are summarized for nine staple foods sampled during a survey conducted for six consecutive quarters from July 1962 through October 1963. Insofar as possible, the results have been grouped by the six broad geographical production regions that were previously used for comparing strontium–90 data for the same samples.

The general trend of the cesium–137 to potassium ratios was similar to the strontium–90 to calcium ratios previously reported, being generally higher in fruits and vegetables than in milk; however, the lowest ratios were found in lettuce, cabbages, potatoes, and eggs. It was noted that the region-to-region variations of cesium–137 concentrations were greater than those of strontium–90 for whole milk, evaporated milk, bread, apples, and oranges.

As part of its program to assess radiation exposure from foods, the Division of Radiological Health has determined the cesium–137 content of selected staple foods sampled during six consecutive quarters beginning in July 1962. For the reader's information it is pointed out that food consumption data were obtained by separate concurrent household surveys conducted from July 1962 to April 1963. A part of the food consumption data was previously reported (*1*, *2*). The sampling and analytical procedures used to develop cesium–137 data for this report have been described in a previous summary of strontium–90 results for the same samples (*3*).

Table 1 summarizes the number of cesium–137 analyses of each kind of food conducted during each survey quarter. Detailed analytical results for cesium–137 concentrations, and cesium–137 to potassium ratios are summarized in the appendix by respective maximum, minimum, median, arithmetic mean, and U.S. average values for all foods, regions (see figure 1), and survey periods.

**Table 1. Number of food samples analyzed for cesium-137 collected in conterminous United States, by survey quarters**

| Food samples | 1962 | | 1963 | | | | Total |
|---|---|---|---|---|---|---|---|
| | July | Oct | Jan | Apr | July | Oct | |
| Milk: whole [a] | 91 | 84 | 93 | 117 | 117 | 110 | 612 |
| evaporated | NS | 48 | 35 | 34 | 25 | 28 | 170 |
| Bread: white | 61 | 50 | 44 | 45 | 55 | 53 | 308 |
| Fruit: apples | 13 | 47 | 29 | 25 | NS | NS | 114 |
| oranges | NS | NS | NS | NS | 14 | 11 | 25 |
| Meat: beef | 13 | 14 | 13 | 12 | NS | NS | 52 |
| pork | NS | NS | NS | NS | 21 | 25 | 46 |
| Vegetables: lettuce | 40 | 26 | 24 | 15 | NS | NS | 105 |
| cabbage | NS | NS | NS | NS | 24 | 32 | 56 |
| Eggs | NS | NS | 27 | 27 | 26 | 25 | 105 |
| Potatoes | NS | NS | 18 | 27 | 31 | 33 | 109 |
| Oleomargarine | NS | NS | 29 | 27 | NS | NS | 56 |
| Cereal | NS | NS | NS | NS | 34 | 33 | 67 |
| Total | 218 | 269 | 312 | 329 | 347 | 350 | |
| Grand total [b] | | | | | | | 1,825 |

[a] Regular pasteurized milk network samples of the Division of Radiological Health collected in the Bureau of Census regions during the household survey periods.
[b] Excluding coffee
NS, no samples collected

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**Figure 1. Regional areas for 1962–1963 food survey—modified regions used by Morgan (*4*)**

*Interlaboratory comparison of analyses*

Analytical control studies performed by the three participating Division laboratories indicated agreement within plus or minus 25 percent of the mean cesium–137 to potassium ratio for 18 of 21 diet cross-check samples. Cross-check milk sample results showed agreement within plus or minus 5 percent of mean cesium–137 concentrations and plus or minus 8 percent of mean potassium concentrations.

*Average cesium–137 contents of U.S. foods*

Among the survey results for the conterminous United States (figure 2), the cesium–137 concentrations and cesium–137 to potassium ratios for evaporated milk, whole milk, meat, and bread generally increased throughout the study with a sharp rise appearing between the fourth and fifth quarters. It is of interest to note that similar patterns were found in the strontium–90 and strontium–90 to calcium ratios for these foods, as previously reported (*3*).

Foods having the highest cesium–137 concentration and cesium–137 to potassium ratio in this survey were evaporated milk, whole milk, cereals, and bread; foods having the lowest concentration of cesium–137 were oleomargarine, eggs, lettuce, potatoes, and apples. Eggs, potatoes, and leaf vegetables had particularly low cesium–137 to potassium ratios.

In comparing cesium–137 content with previously reported strontium–90 content of foods (*3*), it is noted that most foods having low concentrations of cesium–137 also have low concentrations of strontium–90, and vice versa. Notable exceptions include meat, which was low in strontium–90 and high in cesium–137; lettuce and cabbage had comparatively high strontium–90 contents but were low in cesium–137.

*Regional variation of cesium–137 by sampling periods*

Except for somewhat reduced cesium–137 concentrations in foods of the Southwest, the cesium–137 concentrations in foods of the other five regions had a common mean value each quarter. Consequently, a detailed regional examination of the results for each sampling period appeared of limited value.

*Regional variation of cesium–137 by harvest years*

The average of median and mean values for each sampling has been used for harvest year

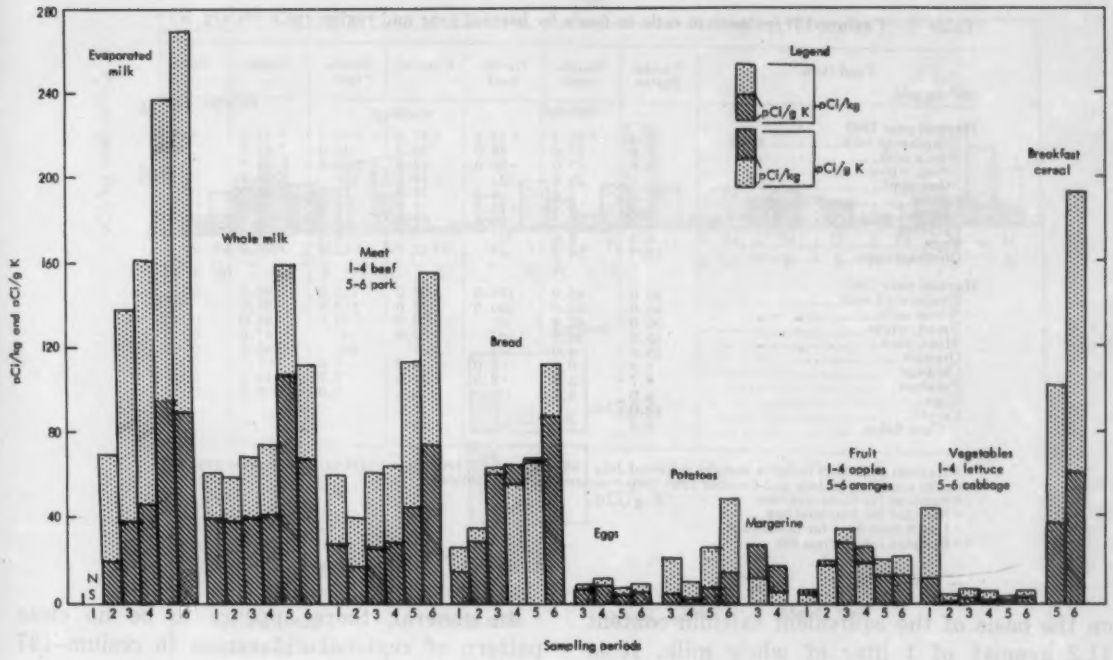


**Figure 2. U.S. average cesium–137 in food by sampling period**

comparisons of cesium–137 in whole milk (pCi/liter) and other foods (pCi/kg). The four sampling periods from July 1962 through April 1963 define harvest year 1962, and the sampling periods of July and October 1963 have been considered representative of harvest year 1963. These results are presented in tables 2 and 3 and plotted in figure 3. For comparison with whole milk values, the evaporated milk was computed as reconstituted evaporated milk

**Table 2. Cesium-137 in foods by harvest year and region (concentrations in pCi/kg) [a]**

| Food item | United States | Southwest | Northwest | Central | Northeast | South | Delta |
|---|---|---|---|---|---|---|---|
| Harvest year 1962 | | | | | | | |
| Evaporated milk | 113.0 | [b] 90.0 | [b] 119.0 | [b] 122.0 | [b] 116.0 | [b] 138.0 | [c] 92.0 |
| Reconstituted evaporated milk [d] | 60.0 | 45.3 | 60.2 | 61.5 | 58.8 | 69.7 | 46.4 |
| Whole milk [e] | 61.5 | 39.4 | 73.4 | 57.2 | 73.8 | 58.4 | 66.9 |
| Meat, beef | 47.5 | 52.0 | (f) | 43.0 | (f) | [b] 47.8 | (f) |
| Bread, white | 43.6 | 40.0 | [c] 33.0 | 42.0 | [c] 62.0 | 37.0 | (f) |
| Apples | 14.7 | 4.0 | 12.7 | 15.5 | 25.7 | 16.0 | (f) |
| Lettuce | 12.0 | 25.0 | [c] 26.0 | 5.0 | [b] 2.0 | 2.5 | (f) |
| Potatoes | 14.0 | [c] 14.5 | [c] 11.2 | [c] 5.7 | [c] 14.0 | 35.0 | (f) |
| Eggs | 8.0 | 3.0 | (f) | 9.5 | 13.2 | 5.7 | (f) |
| Oleomargarine | 6.5 | [s] 1.0 | (f) | [s] 5.2 | [s] 10.7 | [s] 9.0 | (f) |
| Harvest year 1963 | | | | | | | |
| Evaporated milk | 208.0 | 157.0 | [s] 331.0 | [s] 306.0 | 381.0 | 303.0 | (f) |
| Reconstituted evaporated milk [d] | 157.0 | 83.0 | 174.0 | 161.0 | 200.0 | 159.0 | (f) |
| Whole milk [e] | 131.0 | 73.0 | 181.0 | 112.0 | 176.0 | 122.0 | 121.0 |
| Meat, pork | 118.0 | 97.0 | (f) | 133.0 | (f) | 128.0 | (f) |
| Bread, white | 83.0 | 62.0 | (f) | 89.0 | 81.0 | 101.0 | (f) |
| Oranges | (f) | 7.2 | (f) | (f) | (f) | 74.0 | (f) |
| Cabbage | 2.8 | 0.5 | [s] 0.0 | 0.7 | 2.5 | [s] 7.2 | (f) |
| Potatoes | 36.6 | [s] 11.2 | [s] 36.0 | 43.5 | 35.0 | [s] 57.0 | (f) |
| Eggs | 5.5 | 6.0 | (f) | 3.5 | 0.0 | [s] 12.7 | (f) |
| Cereal: | 146.0 | | | | | | |
| Corn flakes | 5.0 | | | | | | |

[a] Sampled for four quarters in 1962 and for 2 quarters in 1963 except as follows:
[b] Sampled for three quarters
[c] Sampled for two quarters
[d] Reconstituted to calcium content in 1 liter of whole milk
[e] pCi/liter
[f] Insufficient data for calculation
[s] Sampled for one quarter

Table 3. Cesium-137/potassium ratio in foods by harvest year and region (pCi $^{137}Cs$/g K) [a]

| Food item | United States | Southwest | Northwest | Central | Northeast | South | Delta |
|---|---|---|---|---|---|---|---|
| Harvest year 1962 | | | | | | | |
| Evaporated milk | 40.4 | [b] 23.4 | [b] 45.2 | [b] 37.4 | [b] 46.7 | [b] 42.0 | [c] 48.0 |
| Whole milk | 37.8 | 27.0 | 38.0 | 36.0 | 43.0 | [b] 42.0 | 40.0 |
| Bread, white | 43.0 | 47.0 | [c] 50.0 | 42.0 | [c] 56.0 | 30.0 | [d] |
| Meat, beef | 19.7 | 23.6 | [d] | 19.1 | [d] | 22.2 | [d] |
| Apples | 11.8 | 3.4 | 6.0 | 13.0 | 23.0 | 13.0 | [d] |
| Lettuce | 4.0 | 3.1 | [c] 13.5 | 1.7 | [b] 1.2 | 0.5 | [d] |
| Potatoes | 2.5 | [c] 3.7 | [c] 2.5 | [c] 1.2 | [c] 3.5 | [c] 8.0 | [d] |
| Eggs | 6.2 | 2.0 | [d] | 8.7 | 9.2 | 4.0 | [d] |
| Oleomargarine | 18.2 | [c] 3.2 | [d] | [c] 12.7 | [c] 32.0 | [c] 25.0 | [d] |
| Harvest year 1963 | | | | | | | |
| Evaporated milk | 90.0 | 46.0 | [c] 109.0 | [c] 88.0 | 112.0 | 96.0 | [d] |
| Whole milk | 85.0 | 51.0 | 120.0 | 70.0 | 113.0 | 81.0 | 82.0 |
| Bread, white | 89.0 | 83.0 | [d] | 98.0 | 93.0 | 81.0 | [d] |
| Meat, pork | 49.0 | 48.0 | [d] | 52.0 | [d] | 47.0 | [d] |
| Oranges | 25.0 | 4.0 | [d] | [d] | [d] | 46.0 | [d] |
| Cabbage | 1.3 | 0.2 | [c] 0.0 | 0.2 | 2.0 | [c] 7.0 | [d] |
| Potatoes | 8.7 | [c] 3.2 | [c] 9.5 | 11.0 | 7.7 | [c] 12.0 | [d] |
| Eggs | 4.0 | 4.2 | [d] | 2.5 | 0.0 | 9.2 | [d] |
| Cereal: | 48.0 | | | | | | |
| Corn flakes | 5.2 | | | | | | |

[a] Harvest year 1962 includes samples collected July 1962 to April 15, 1963 (four quarters) and harvest year 1963 includes sampling in July and October 1963 (two quarters) except as follows:
[b] Sampled for three quarters
[c] Sampled for two quarters
[d] Insufficient data for calculation
[e] Sampled for one quarter

on the basis of the equivalent calcium content (1.2 grams) of 1 liter of whole milk. It is evident that the whole milk usually had less cesium–137 than the reconstituted evaporated milk.

Reconstituted evaporated milk and whole milk had similar cesium–137 contents and cesium–137 to potassium ratios for each of the regions in harvest year 1962. The values for the Southwest averaged about 35 percent lower than those of the other regions. This pattern was repeated in harvest year 1963 with certain exceptions. Although the Southwest samples again had the least amount of cesium–137 in milk, the concentrations were about twice as high in 1963 as in 1962 and varied more in the other regions.

Foods having the highest cesium–137 concentrations (ranging from 33 to 74 pCi/kg) in harvest year 1962 were reconstituted evaporated milk, whole milk, bread, and meat. The same foods again had the highest cesium–137 concentrations in harvest year 1963, but at substantially higher levels (ranging from 60 to 200 pCi/kg). Potatoes also showed marked increases in cesium–137 content in harvest year 1963. The cesium–137 content of cabbage was found to be low in 1963, and in most regions was lower than that of lettuce sampled in 1962.

In general, there appears to be no clear pattern of regional differences in cesium–137 content in foods by harvest years except for the relatively low levels in milk from the Southwest. The general trend of the cesium–137 to potassium ratios appears similar to that of strontium–90 to calcium previously reported (*3*); however, variations from region to region are greater for whole milk, evaporated milk, bread, apples, and oranges.

*Harvest year ratio comparisons*

Six of the foods sampled in 1962 were also sampled in 1963. Meat is included with these even though beef was sampled in 1962 and pork was sampled in 1963. The magnitude of the cesium–137 to potassium ratios for these foods in 1963 relative to the 1962 ratios are shown in table 4.

Considering first whole milk and evaporated milk, it may be noted that the 1963/1962 ratios vary from 1.89 in the Southwest to 3.16 in the Northwest with a median value of 2.28. If to these two foods are added the values for bread, meat, potatoes, and eggs, the ranges are wider: (0.2 for meat in the South to 9.2 for potatoes in the Central region), although the median (at 2.06) is relatively unchanged. In the previous report it may be observed that the ratio of calcium for the 2 years 1963/1962, was 1.8.

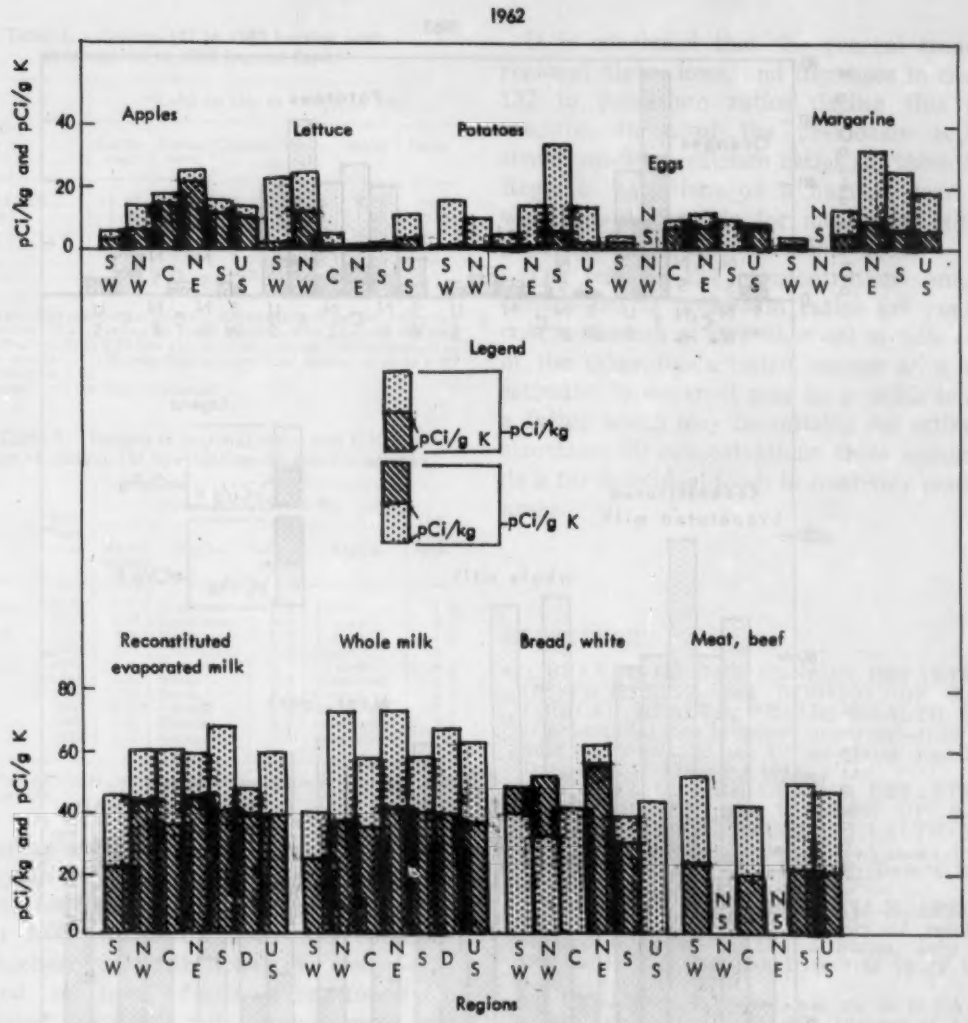


Figure 3. Cesium–137 in foods during harvest year 1962

A similar compilation of the cesium–137 results for the 2 years gives a value of 2.24 for milk and an average value of 2.25 for the five foods (whole and evaporated milk, bread, eggs, and potatoes) or an apparent greater relative increase of 25 percent for cesium–137 over that observed for strontium–90.

*The ratio of cesium–137 to strontium–90 as an indicator*

Cesium–137 determinations are usually nondestructive examinations of samples by multichannel gamma spectrometry, whereas radiochemical techniques which are time-consuming and relatively expensive are necessary for determining strontium–90. The use of cesium–137 concentrations to estimate the strontium–90 content is therefore of considerable practical interest. For a general treatment of the subject, ratios of the cesium–137 concentration in table 2 as compared to the strontium–90 concentrations previously reported (*3*) were derived for the six foods common to both harvest years. The results in table 5 show that

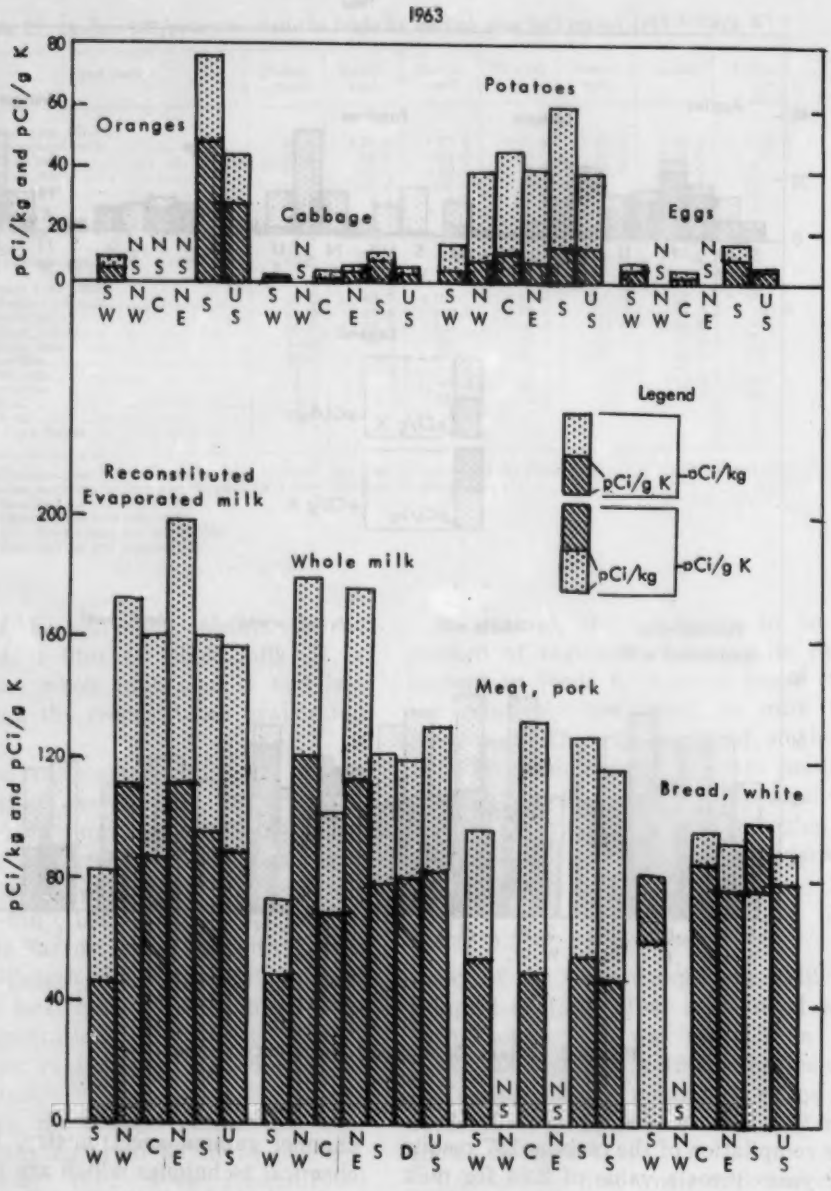


**Figure 3—continued. Cesium–137 in foods during harvest year 1963**

the ratios of cesium–137 to strontium–90 vary widely between regions for most of the foods, ranging from 11.7 for 1962 potatoes to 0.4 for 1963 eggs. The smallest variation in cesium–137 to strontium–90 ratio for any food was observed in bread, ranging from 3.1 to 4.6 over both harvest years and all regions.

Nevertheless, the average ratio for the five foods in table 5 is about 4, or a very rough approximation of the strontium–90 would be one-fourth the cesium–137 concentration.

### *Summary and conclusions*

Cesium–137 concentrations and cesium–137 to potassium ratios for foods sampled during

**Table 4. Cesium-137 in 1963 harvest food as compared to 1962 harvest food [a]**

| Food | $^{137}Cs/K$ for 1963 to $^{137}Cs/K$ for 1962 | | | | | |
|---|---|---|---|---|---|---|
| | Southwest | Northwest | Central | Northeast | South | Delta |
| Evaporated milk | 1.97 | 2.41 | 2.35 | 2.40 | 2.28 | (b) |
| Whole milk | 1.89 | 3.16 | 1.04 | 2.63 | 1.93 | 2.05 |
| Bread | 1.77 | (b) | 2.33 | 1.67 | 2.70 | (b) |
| Meat | 2.06 | (b) | 2.72 | (b) | 0.20 | (b) |
| Potatoes | 0.87 | 3.80 | 9.20 | 2.20 | 1.50 | (b) |
| Eggs | 2.10 | (b) | 0.29 | 0.0 | 1.84 | (b) |

[a] Foods including meat which were not common in both harvest years and their respective $^{137}Cs/K$ ratios for the 2 years were as follows: 1963 lean pork/1962 beef—0.20 to 2.72 (see above), 1963 cabbage/1962 lettuce—0 to 14 with an average of 0.33, and 1963 oranges/1962 apples—2.12 to 3.55 with an average of 2.83.
[b] Insufficient data for ratio calculation

**Table 5. Ranges of regional ratios and U.S. average of cesium-137 to strontium-90 concentrations [a]**

| Food | Harvest year | Range, pCi $^{137}Cs$/pCi $^{90}Sr$ | | | | U.S. average |
|---|---|---|---|---|---|---|
| | | Maximum | Region | Minimum | Region | |
| Whole milk | 1962 | 6.0 | Southwest | 2.2 | Delta | 3.8 |
| | 1963 | 5.8 | Southwest | 3.4 | Delta | 4.7 |
| Evaporated milk | 1962 | 7.1 | Northwest | 2.1 | Delta | 4.0 |
| | 1963 | 7.5 | Northeast | 4.3 | South | 6.1 |
| Bread | 1962 | 4.6 | Northeast | 3.1 | Central | 3.9 |
| | 1963 | 4.5 | South | 3.8 | Southwest | 4.0 |
| Potatoes | 1962 | 11.7 | South | 2.6 | Central | 4.7 |
| | 1963 | 10.9 | Central | 3.5 | Southwest | 7.5 |
| Eggs | 1962 | 5.6 | Central | 0.7 | Southwest | 2.8 |
| | 1963 | 3.2 | South | 0.4 | Central | 1.0 |

[a] Strontium-90 results used to evaluate these ratios were taken from an earlier report (*3*).

this survey are summarized, grouping the results by six broad geographical regions of production, insofar as possible, irrespective of the market from which the food was collected. The highest concentrations of cesium–137 observed in these foods were found in evaporated and whole milk, cereals, meat, and bread.

It is concluded that the general trends of regional highs, lows, and increases in cesium–137 to potassium ratios during this study resemble those of the previously reported strontium–90 to calcium ratios for these foods. Regional variations on a harvest year basis were less discernible for meat (beef or lean pork) and eggs than for other foods.

The cesium–137 concentration and the cesium–137 to potassium ratios are generally poor indicators of strontium–90 in milk or any of the other foods tested, except as a rough estimate; however, it may be possible to apply a factor which may be suitable for estimating strontium–90 concentrations from cesium–137 data for individual foods in relatively restricted areas.

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## Appendix. Cesium-137 in milk and food, July 1962–October 1963

| Food | Region | Month and year | Number of samples | Cesium-137 | | | | Cesium-137/potassium, pCi/g | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minimum | Maximum | Median | Mean | Minimum | Maximum | Median | Mean |
| Milk, evaporated (concentration in pCi/kg) | Southwest | *1962* | | | | | | | | | |
| | | Oct | 10 | 0 | 112 | 57 | 58 | 0 | 43 | 16 | 19 |
| | | *1963* | | | | | | | | | |
| | | Jan | 10 | 20 | 200 | 88 | 92 | 6 | 67 | 29 | 29 |
| | | Apr | 9 | 30 | 350 | 120 | 123 | 8 | 102 | 34 | 35 |
| | | July | 10 | 140 | 310 | 192 | 205 | 44 | 90 | 56 | 60 |
| | | Oct | 7 | 65 | 350 | 92 | 141 | 19 | 109 | 27 | 41 |
| | Northwest | *1962* | | | | | | | | | |
| | | Oct | 4 | 40 | 150 | 107 | 101 | 13 | 52 | 41 | 37 |
| | | *1963* | | | | | | | | | |
| | | Jan | 1 | — | — | — | 110 | — | — | — | 37 |
| | | Apr | 3 | 95 | 100 | 150 | 135 | 28 | 44 | 42 | 38 |
| | | Oct | 3 | 80 | 390 | 380 | 283 | 52 | 120 | 113 | 105 |
| | Central | *1962* | | | | | | | | | |
| | | Oct | 16 | 0 | 170 | 0 | 60 | 0 | 51 | 0 | 18 |
| | | *1963* | | | | | | | | | |
| | | Jan | 8 | 45 | 230 | 160 | 153 | 13 | 69 | 47 | 45 |
| | | Apr | 11 | 130 | 200 | 180 | 177 | 37 | 64 | 53 | 52 |
| | | Oct | 3 | 290 | 350 | 300 | 313 | 78 | 109 | 86 | 90 |
| | Northeast | *1962* | | | | | | | | | |
| | | Oct | 4 | 130 | 250 | 155 | 172 | 35 | 78 | 40 | 48 |
| | | *1963* | | | | | | | | | |
| | | Jan | 6 | 25 | 230 | 140 | 135 | 7 | 56 | 39 | 36 |
| | | Apr | 5 | 150 | 190 | 160 | 166 | 41 | 54 | 46 | 47 |
| | | July | 8 | 140 | 450 | 335 | 325 | 39 | 140 | 113 | 95 |
| | | Oct | 8 | 290 | 640 | 430 | 434 | 85 | 139 | 116 | 123 |
| | South | *1962* | | | | | | | | | |
| | | Oct | 10 | 0 | 140 | 0 | 24 | 0 | 42 | 0 | 16 |
| | | *1963* | | | | | | | | | |
| | | Jan | 10 | 80 | 250 | 190 | 171 | 24 | 72 | 54 | 50 |
| | | Apr | 3 | 160 | 250 | 230 | 213 | 49 | 78 | 72 | 66 |
| | | July | 7 | 170 | 1,900 | 220 | 504 | 45 | 619 | 72 | 155 |
| | | Oct | 7 | 130 | 400 | 225 | 263 | 44 | 120 | 71 | 85 |
| | Delta | *1962* | | | | | | | | | |
| | | Oct | 4 | 0 | 240 | 85 | 102 | 0 | 70 | 20 | 28 |
| | | *1963* | | | | | | | | | |
| | | Apr | 3 | 140 | 190 | 190 | 173 | 44 | 64 | 58 | 55 |
| | United States | *1962* | | | | | | | | | |
| | | Oct | 48 | | | | 71.0 | | | | 22.0 |
| | | *1963* | | | | | | | | | |
| | | Jan | 35 | | | | 136.0 | | | | 40.0 |
| | | Apr | 34 | | | | 160.0 | | | | 47.0 |
| | | July | 25 | | | | 237.0 | | | | 97.0 |
| | | Oct | 28 | | | | 268.0 | | | | 91.0 |
| Milk, fluid (concentration in pCi/liter) | Southwest | *1962* | | | | | | | | | |
| | | July | 13 | 0 | 95 | 10 | 27 | 0 | 67 | 6 | 18 |
| | | Oct | 7 | 15 | 170 | 40 | 41 | 7 | 131 | 13 | 33 |
| | | *1963* | | | | | | | | | |
| | | Jan | 7 | 20 | 90 | 40 | 41 | 11 | 60 | 18 | 25 |
| | | Apr | 14 | 0 | 150 | 57 | 59 | 0 | 115 | 35 | 39 |
| | | July | 14 | 15 | 290 | 52 | 102 | 10 | 203 | 48 | 65 |
| | | Oct | 10 | 30 | 190 | 50 | 90 | 18 | 122 | 37 | 53 |
| | Northwest | *1962* | | | | | | | | | |
| | | July | 10 | 35 | 75 | 67 | 54 | 25 | 46 | 38 | 38 |
| | | Oct | 9 | 55 | 110 | 70 | 79 | 36 | 73 | 44 | 49 |
| | | *1963* | | | | | | | | | |
| | | Jan | 6 | 0 | 90 | 82 | 63 | 0 | 52 | 42 | 38 |
| | | Apr | 12 | 70 | 145 | 82 | 90 | 46 | 103 | 53 | 59 |
| | | July | 12 | 130 | 290 | 205 | 211 | 73 | 226 | 149 | 146 |
| | | Oct | 11 | 110 | 200 | 150 | 157 | 67 | 128 | 89 | 96 |
| | Central | *1962* | | | | | | | | | |
| | | July | 24 | 10 | 80 | 47 | 50 | 6 | 53 | 34 | 35 |
| | | Oct | 25 | 0 | 100 | 45 | 51 | 0 | 66 | 30 | 33 |
| | | *1963* | | | | | | | | | |
| | | Jan | 22 | 35 | 85 | 70 | 65 | 22 | 54 | 40 | 40 |
| | | Apr | 30 | 0 | 110 | 65 | 65 | 26 | 73 | 42 | 45 |
| | | July | 30 | 70 | 210 | 130 | 130 | 45 | 153 | 81 | 85 |
| | | Oct | 29 | 60 | 150 | 90 | 98 | 33 | 90 | 53 | 59 |
| | Northeast | *1962* | | | | | | | | | |
| | | July | 27 | 35 | 150 | 75 | 82 | 26 | 111 | 50 | 56 |
| | | Oct | 27 | 0 | 130 | 70 | 67 | 0 | 81 | 44 | 41 |
| | | *1963* | | | | | | | | | |
| | | Jan | 28 | 45 | 130 | 75 | 79 | 31 | 83 | 45 | 48 |
| | | Apr | 29 | 40 | 120 | 70 | 72 | 25 | 61 | 44 | 46 |
| | | July | 30 | 120 | 360 | 200 | 210 | 72 | 225 | 134 | 135 |
| | | Oct | 30 | 70 | 280 | 140 | 155 | 51 | 177 | 85 | 97 |
| | South | *1962* | | | | | | | | | |
| | | July | 10 | 0 | 110 | 53 | 53 | 0 | 91 | 39 | 39 |
| | | Oct | 12 | 20 | 115 | 45 | 49 | 15 | 88 | 31 | 35 |
| | | *1963* | | | | | | | | | |
| | | Jan | 23 | 0 | 100 | 55 | 54 | 0 | 71 | 39 | 37 |
| | | Apr | 24 | 40 | 180 | 75 | 83 | 27 | 128 | 54 | 60 |
| | | July | 23 | 45 | 270 | 140 | 146 | 30 | 203 | 88 | 98 |
| | | Oct | 22 | 40 | 330 | 97 | 107 | 28 | 212 | 65 | 74 |

## Appendix—continued

| Food | Region | Month and year | Number of samples | Cesium-137 | | | | Cesium-137/potassium, pCi/g | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minimum | Maximum | Median | Mean | Minimum | Maximum | Median | Mean |
| Milk, fluid—continued | Delta | *1962* | | | | | | | | | |
| | | July | 7 | 40 | 100 | 70 | 68 | 32 | 81 | 50 | 50 |
| | | Oct | 4 | 30 | 55 | 35 | 39 | 21 | 39 | 25 | 28 |
| | | *1963* | | | | | | | | | |
| | | Jan | 7 | 30 | 75 | 55 | 52 | 21 | 54 | 42 | 38 |
| | | Apr | 8 | 55 | 140 | 110 | 106 | 36 | 100 | 78 | 76 |
| | | July | 8 | 80 | 170 | 140 | 136 | 52 | 112 | 100 | 91 |
| | | Oct | 8 | 70 | 140 | 105 | 102 | 43 | 95 | 71 | 68 |
| | United States | *1962* | | | | | | | | | |
| | | July | 91 | | | | 58.3 | | | | 40.7 |
| | | Oct | 84 | | | | 57.4 | | | | 39.4 |
| | | *1963* | | | | | | | | | |
| | | Jan | 93 | | | | 64.0 | | | | 40.0 |
| | | Apr | 117 | | | | 75.0 | | | | 43.0 |
| | | July | 117 | | | | 160.0 | | | | 106.0 |
| | | Oct | 110 | | | | 114.0 | | | | 71.0 |
| Bread (concentration in pCi/kg) | Southwest | *1962* | | | | | | | | | |
| | | July | 8 | 10 | 55 | 40 | 26 | 0 | 91 | 37 | 45 |
| | | Oct | 10 | 20 | 75 | 50 | 48 | 22 | 81 | 55 | 53 |
| | | *1963* | | | | | | | | | |
| | | Jan | 13 | 0 | 50 | 35 | 33 | 0 | 92 | 43 | 40 |
| | | Apr | 15 | 30 | 80 | 45 | 47 | 33 | 85 | 53 | 52 |
| | | July | 12 | 30 | 75 | 45 | 48 | 31 | 119 | 59 | 60 |
| | | Oct | 11 | 60 | 95 | 75 | 77 | 81 | 173 | 119 | 116 |
| | Northwest | *1962* | | | | | | | | | |
| | | July | 9 | 20 | 65 | 30 | 39 | 31 | 130 | 42 | 51 |
| | | Oct | 4 | 25 | 45 | 38 | 36 | 28 | 76 | 56 | 52 |
| | Central | *1962* | | | | | | | | | |
| | | July | 13 | 0 | 50 | 0 | 15 | 0 | 55 | 0 | 25 |
| | | Oct | 20 | 0 | 60 | 13 | 21 | 0 | 94 | 19 | 27 |
| | | *1963* | | | | | | | | | |
| | | Jan | 10 | 0 | 90 | 72 | 64 | 0 | 95 | 74 | 68 |
| | | Apr | 10 | 45 | 90 | 78 | 74 | 47 | 80 | 64 | 63 |
| | | July | 20 | 45 | 90 | 70 | 69 | 53 | 96 | 80 | 72 |
| | | Oct | 20 | 60 | 200 | 110 | 108 | 57 | 162 | 125 | 117 |
| | Northeast | *1962* | | | | | | | | | |
| | | July | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Oct | 5 | 60 | 95 | 75 | 75 | 48 | 87 | 77 | 70 |
| | | *1963* | | | | | | | | | |
| | | Jan | 10 | 25 | 140 | 90 | 90 | 22 | 118 | 83 | 82 |
| | | Apr | 10 | 60 | 95 | 85 | 82 | 47 | 83 | 73 | 69 |
| | | July | 11 | 0 | 120 | 65 | 64 | 0 | 105 | 65 | 60 |
| | | Oct | 7 | 65 | 160 | 90 | 106 | 103 | 173 | 123 | 124 |
| | South | *1962* | | | | | | | | | |
| | | July | 16 | — | — | — | — | 0 | 100 | 0 | 16 |
| | | Oct | 11 | 0 | 50 | 0 | 5 | 0 | 35 | 0 | 3 |
| | | *1963* | | | | | | | | | |
| | | Jan | 11 | 30 | 90 | 65 | 56 | 32 | 95 | 69 | 59 |
| | | Apr | 10 | 20 | 80 | 53 | 51 | 20 | 56 | 42 | 39 |
| | | July | 12 | 35 | 120 | 87 | 77 | 31 | 86 | 57 | 59 |
| | | Oct | 15 | 65 | 170 | 120 | 120 | 60 | 168 | 107 | 103 |
| | Delta | *1962* | | | | | | | | | |
| | | July | 5 | 0 | 344 | 0 | 69 | 0 | 105 | 0 | 3 |
| | United States | *1962* | | | | | | | | | |
| | | July | 61 | | | | 12.2 | | | | 23.2 |
| | | Oct | 50 | | | | 29.5 | | | | 33.2 |
| | | *1963* | | | | | | | | | |
| | | Jan | 44 | | | | 59.0 | | | | 62.0 |
| | | Apr | 45 | | | | 62.0 | | | | 55.0 |
| | | July | 53 | | | | 65.0 | | | | 64.0 |
| | | Oct | 53 | | | | 87.0 | | | | 109.0 |
| Lettuce (concentration in pCi/kg) | Southwest | *1962* | | | | | | | | | |
| | | July | 8 | 0 | 900 | 15 | 164 | 0 | 68 | 2 | 14 |
| | | Oct | 9 | 0 | 50 | 0 | 6 | 0 | 19 | 0 | 2 |
| | | *1963* | | | | | | | | | |
| | | Jan | 15 | 0 | 35 | 0 | 2 | 0 | 8 | 0 | 1 |
| | | Apr | 6 | 0 | 40 | 0 | 10 | 0 | 15 | 0 | 6 |
| | Northwest | *1962* | | | | | | | | | |
| | | July | 5 | 25 | 65 | 53 | 47 | 20 | 35 | 27 | 26 |
| | | Oct | 4 | 0 | 15 | 0 | 4 | 0 | 13 | 0 | 3 |
| | Central | *1962* | | | | | | | | | |
| | | July | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Oct | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | *1963* | | | | | | | | | |
| | | Jan | 6 | 0 | 50 | 20 | 22 | 0 | 13 | 7 | 7 |
| | | Apr | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Northeast | *1962* | | | | | | | | | |
| | | July | 10 | 0 | 117 | 0 | 12 | 0 | 90 | 0 | 9 |
| | | Oct | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | *1963* | | | | | | | | | |
| | | Apr | 1 | — | — | — | 0 | — | — | — | 0 |

## Appendix—continued

| Food | Region | Month and year | Number of samples | Cesium-137 | | | | Cesium-137/potassium, pCi/g | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minimum | Maximum | Median | Mean | Minimum | Maximum | Median | Mean |
| Lettuce—continued | South | *1962* | | | | | | | | | |
| | | July | 1 | — | — | — | 0 | — | — | — | 0 |
| | | Oct | 1 | — | — | — | 0 | — | — | — | 0 |
| | | *1963* | | | | | | | | | |
| | | Jan | 3 | 0 | 15 | 0 | 5 | 0 | 4 | 0 | 2 |
| | | Apr | 4 | 0 | 20 | 0 | 5 | 0 | 10 | 0 | 2 |
| | United States | *1962* | | | | | | | | | |
| | | July | 40 | | | | 42.0 | | | | 8.0 |
| | | Oct | 26 | | | | 3.0 | | | | 1.0 |
| | | *1963* | | | | | | | | | |
| | | Jan | 24 | | | | 7.5 | | | | 2.3 |
| | | Apr | 15 | | | | 6.0 | | | | 2.4 |
| Cabbage (concentration in pCi/kg) | Southwest | *1963* | | | | | | | | | |
| | | July | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Oct | 6 | 0 | 10 | 0 | 2 | 0 | 5 | 0 | 1 |
| | Northwest | *1963* | | | | | | | | | |
| | | Oct | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Central | *1963* | | | | | | | | | |
| | | July | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Oct | 11 | 0 | 15 | 0 | 3 | 0 | 9 | 0 | 1 |
| | Northeast | *1963* | | | | | | | | | |
| | | July | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Oct | 13 | 0 | 75 | 0 | 10 | 0 | 28 | 0 | 4 |
| | South | *1963* | | | | | | | | | |
| | | July | 5 | 0 | 25 | 15 | 14 | 0 | 13 | 8 | 7 |
| | United States | *1963* | | | | | | | | | |
| | | July | 24 | | | | 2.9 | | | | 1.4 |
| | | Oct | 32 | | | | 5.3 | | | | 2.4 |
| Waste | | *1963* | | | | | | | | | |
| | | July | 6 | 0 | 120 | 20 | 42 | 0 | 36 | 7 | 15 |
| | | Oct | 8 | 0 | 55 | 30 | 32 | 0 | 18 | 9 | 9 |
| Apples (concentration in pCi/kg) | Southwest | *1962* | | | | | | | | | |
| | | July | 1 | — | — | — | 0 | — | — | — | 0 |
| | | Oct | 5 | 0 | 5 | 0 | 1 | 0 | 4 | 0 | 1 |
| | | *1963* | | | | | | | | | |
| | | Jan | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Apr | 2 | 15 | 15 | 15 | 15 | 12 | 14 | 13 | 13 |
| | Northwest | *1962* | | | | | | | | | |
| | | July | 4 | 0 | 25 | 15 | 14 | 0 | 25 | 18 | 15 |
| | | Oct | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | *1963* | | | | | | | | | |
| | | Jan | 5 | 0 | 60 | 0 | 15 | 0 | 42 | 0 | 12 |
| | | Apr | 6 | 10 | 65 | 25 | 33 | 9 | 23 | 18 | 17 |
| | Central | *1962* | | | | | | | | | |
| | | July | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Oct | 15 | 0 | 40 | 0 | 16 | 0 | 39 | 0 | 15 |
| | | *1963* | | | | | | | | | |
| | | Jan | 8 | 25 | 80 | 37 | 44 | 20 | 58 | 32 | 36 |
| | | Apr | 4 | 0 | 30 | 13 | 14 | 0 | 26 | 10 | 14 |
| | Northeast | *1962* | | | | | | | | | |
| | | July | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Oct | 15 | 0 | 55 | 35 | 35 | 0 | 68 | 29 | 37 |
| | | *1963* | | | | | | | | | |
| | | Jan | 10 | 25 | 80 | 45 | 46 | 20 | 70 | 41 | 40 |
| | | Apr | 10 | 0 | 50 | 25 | 20 | 0 | 53 | 19 | 20 |
| | South | *1962* | | | | | | | | | |
| | | July | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Oct | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | *1963* | | | | | | | | | |
| | | Jan | 4 | 30 | 45 | 30 | 34 | 25 | 37 | 25 | 28 |
| | | Apr | 3 | 25 | 45 | 30 | 33 | 20 | 31 | 27 | 26 |
| | United States | *1962* | | | | | | | | | |
| | | July | 13 | | | | 4.3 | | | | 4.6 |
| | | Oct | 47 | | | | 16.3 | | | | 17.1 |
| | | *1963* | | | | | | | | | |
| | | Jan | 29 | | | | 35.2 | | | | 29.1 |
| | | Apr | 25 | | | | 19.0 | | | | 23.0 |
| Oranges (concentration in pCi/kg) | Southwest | *1963* | | | | | | | | | |
| | | July | 12 | 0 | 35 | 7 | 14 | 0 | 18 | 5 | 7 |
| | | Oct | 9 | 0 | 20 | 0 | 8 | 0 | 11 | 0 | 4 |
| | South | *1963* | | | | | | | | | |
| | | July | 2 | 45 | 90 | 68 | 68 | 22 | 55 | 38 | 38 |
| | | Oct | 2 | 75 | 85 | 80 | 80 | 45 | 66 | 54 | 54 |
| | United States | *1963* | | | | | | | | | |
| | | July | 14 | | | | 20.0 | | | | 12.0 |
| | | Oct | 11 | | | | 21.0 | | | | 12.0 |

## Appendix—continued

| Food | Region | Month and year | Number of samples | Cesium-137 | | | | Cesium-137/potassium, pCi/g | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minimum | Maximum | Median | Mean | Minimum | Maximum | Median | Mean |
| Oranges—continued | | | | | | | | | | | |
| Waste | | *1963* | | | | | | | | | |
| | | July | 8 | 25 | 120 | 62 | 64 | 8 | 65 | 39 | 36 |
| | | Oct | 3 | 55 | 240 | 70 | 122 | 31 | 99 | 32 | 57 |
| Eggs (concentration in pCi/kg) | Southwest | *1963* | | | | | | | | | |
| | | Jan | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Apr | 12 | 0 | 20 | 5 | 7 | 0 | 15 | 3 | 5 |
| | | July | 4 | 0 | 15 | 0 | 4 | 0 | 11 | 0 | 3 |
| | | Oct | 5 | 5 | 15 | 10 | 10 | 3 | 10 | 7 | 7 |
| | Central | *1963* | | | | | | | | | |
| | | Jan | 6 | 0 | 20 | 10 | 9 | 0 | 14 | 12 | 7 |
| | | Apr | 6 | 0 | 55 | 5 | 14 | 0 | 37 | 5 | 11 |
| | | July | 8 | 0 | 30 | 0 | 6 | 0 | 22 | 0 | 5 |
| | | Oct | 6 | 0 | 25 | 0 | 8 | 0 | 17 | 0 | 5 |
| | Northeast | *1963* | | | | | | | | | |
| | | Jan | 7 | 0 | 35 | 15 | 16 | 0 | 22 | 9 | 13 |
| | | Apr | 6 | 0 | 25 | 10 | 12 | 0 | 16 | 7 | 8 |
| | | July | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Oct | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | South | *1963* | | | | | | | | | |
| | | Jan | 6 | 0 | 10 | 0 | 3 | 0 | 9 | 3 | 3 |
| | | Apr | 3 | 0 | 20 | 10 | 10 | 0 | 16 | 7 | 7 |
| | | July | 5 | 10 | 20 | 10 | 13 | 7 | 15 | 8 | 10 |
| | | Oct | 6 | 0 | 20 | 15 | 13 | 0 | 15 | 10 | 9 |
| | United States | *1963* | | | | | | | | | |
| | | Jan | 27 | | | | 7.0 | | | | 6.0 |
| | | Apr | 27 | | | | 10.0 | | | | 7.3 |
| | | July | 26 | | | | 5.4 | | | | 4.0 |
| | | Oct | 25 | | | | 7.5 | | | | 5.0 |
| Beef (concentration in pCi/kg) | Southwest | *1962* | | | | | | | | | |
| | | July | 3 | 30 | 140 | 80 | 83 | 12 | 53 | 42 | 36 |
| | | Oct | 2 | 20 | 35 | 27 | 28 | 9 | 15 | 12 | 12 |
| | | *1963* | | | | | | | | | |
| | | Jan | 4 | 25 | 60 | 30 | 37 | 14 | 33 | 16 | 20 |
| | | Apr | 4 | 25 | 85 | 68 | 61 | 10 | 40 | 26 | 25 |
| | Northwest | *1963* | | | | | | | | | |
| | | Jan | 1 | — | — | — | 80 | — | — | — | 26 |
| | Central | *1962* | | | | | | | | | |
| | | July | 3 | 0 | 45 | 0 | 15 | 0 | 18 | 0 | 6 |
| | | Oct | 7 | 0 | 90 | 30 | 32 | 0 | 38 | 13 | 13 |
| | | *1963* | | | | | | | | | |
| | | Jan | 6 | 0 | 240 | 60 | 82 | 0 | 110 | 28 | 36 |
| | | Apr | 8 | 0 | 120 | 60 | 64 | 0 | 56 | 26 | 31 |
| | Northeast | *1962* | | | | | | | | | |
| | | July | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | South | *1962* | | | | | | | | | |
| | | July | 5 | 35 | 290 | 40 | 95 | 0 | 131 | 16 | 46 |
| | | Oct | 5 | 0 | 130 | 25 | 47 | 0 | 64 | 13 | 22 |
| | | *1963* | | | | | | | | | |
| | | Jan | 2 | 15 | 65 | 40 | 40 | 7 | 30 | 18 | 18 |
| | United States | *1962* | | | | | | | | | |
| | | July | 13 | | | | 59.0 | | | | 27.0 |
| | | Oct | 14 | | | | 37.0 | | | | 16.0 |
| | | *1963* | | | | | | | | | |
| | | Jan | 13 | | | | 61.0 | | | | 28.0 |
| | | Apr | 12 | | | | 64.0 | | | | 29.0 |
| Pork (concentration in pCi/kg) | Southwest | *1963* | | | | | | | | | |
| | | July | 3 | 30 | 90 | 75 | 65 | 20 | 44 | 38 | 35 |
| | | Oct | 2 | 110 | 140 | 125 | 125 | 59 | 62 | 60 | 60 |
| | Central | *1963* | | | | | | | | | |
| | | July | 11 | 35 | 440 | 110 | 120 | 19 | 132 | 47 | 53 |
| | | Oct | 15 | 55 | 500 | 130 | 171 | 17 | 187 | 51 | 59 |
| | South | *1963* | | | | | | | | | |
| | | July | 7 | 60 | 170 | 120 | 119 | 26 | 62 | 43 | 42 |
| | | Oct | 8 | 45 | 240 | 140 | 133 | 18 | 110 | 54 | 51 |
| | United States | *1963* | | | | | | | | | |
| | | July | 20 | | | | 112.0 | | | | 46.0 |
| | | Oct | 32 | | | | 154.0 | | | | 73.0 |
| Waste—bone | | *1963* | | | | | | | | | |
| | | July | 9 | 0 | 180 | 65 | 84 | 0 | 132 | 43 | 46 |
| | | Oct | 13 | 25 | 85 | 50 | 67 | 12 | 87 | 29 | 37 |
| Potatoes (concentration in pCi/kg) | Southwest | *1963* | | | | | | | | | |
| | | Jan | 2 | 0 | 30 | 15 | 15 | 2 | 6 | 4 | 4 |
| | | Apr | 4 | 0 | 20 | 15 | 13 | 0 | 5 | 4 | 3 |
| | | July | 16 | 0 | 40 | 0 | 10 | 0 | 11 | 0 | 3 |
| | | Oct | 4 | 0 | 50 | 15 | 20 | 0 | 11 | 5 | 5 |

## Appendix—continued

| Food | Region | Month and year | Number of samples | Cesium-137 | | | | Cesium-137/potassium, pCi/g | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minimum | Maximum | Median | Mean | Minimum | Maximum | Median | Mean |
| Potatoes—Continued | Northwest | *1963* | | | | | | | | | |
| | | Jan | 5 | 0 | 35 | 20 | 19 | 0 | 7 | 4 | 4 |
| | | Apr | 4 | 0 | 25 | 0 | 6 | 0 | 5 | 0 | 2 |
| | | Oct | 7 | 10 | 250 | 20 | 52 | 3 | 66 | 6 | 13 |
| | Central | *1963* | | | | | | | | | |
| | | Jan | 3 | 0 | 20 | 10 | 10 | 0 | 4 | 2 | 2 |
| | | Apr | 9 | 0 | 20 | 0 | 3 | 0 | 5 | 0 | 1 |
| | | Oct | 12 | 20 | 85 | 40 | 47 | 5 | 19 | 11 | 11 |
| | Northeast | *1963* | | | | | | | | | |
| | | Jan | 8 | 0 | 55 | 25 | 24 | 0 | 13 | 6 | 6 |
| | | Apr | 8 | 0 | 20 | 0 | 7 | 0 | 5 | 0 | 2 |
| | | July | 6 | 0 | 75 | 0 | 15 | 0 | 17 | 0 | 4 |
| | | Oct | 10 | 45 | 75 | 65 | 60 | 10 | 18 | 14 | 13 |
| | South | *1963* | | | | | | | | | |
| | | Apr | 2 | 35 | 35 | 35 | 35 | 7 | 8 | 8 | 8 |
| | | July | 9 | 25 | 110 | 60 | 55 | 6 | 28 | 12 | 12 |
| | United States | *1963* | | | | | | | | | |
| | | Jan | 18 | | | | 20.0 | | | | 4.7 |
| | | Apr | 27 | | | | 8.5 | | | | 2.4 |
| | | July | 31 | | | | 24.0 | | | | 6.0 |
| | | Oct | 33 | | | | 49.0 | | | | 12.0 |
| Waste | | *1963* | | | | | | | | | |
| | | July | 9 | 0 | 90 | 40 | 38 | 7 | 21 | 8 | 8 |
| | | Oct | 5 | 25 | 110 | 45 | 57 | 5 | 20 | 10 | 11 |
| Oleomargarine (concentration in pCi/kg) | Southwest | *1963* | | | | | | | | | |
| | | Jan | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Apr | 6 | 0 | 25 | 0 | 4 | 0 | 66 | 0 | 13 |
| | Central | *1963* | | | | | | | | | |
| | | Jan | 3 | 0 | 15 | 10 | 8 | 0 | 31 | 26 | 16 |
| | | Apr | 9 | 0 | 15 | 0 | 3 | 0 | 47 | 0 | 9 |
| | Northeast | *1963* | | | | | | | | | |
| | | Jan | 8 | 10 | 35 | 20 | 23 | 27 | 95 | 64 | 64 |
| | | Apr | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | South | *1963* | | | | | | | | | |
| | | Jan | 11 | 0 | 20 | 10 | 7 | 0 | 60 | 30 | 17 |
| | | Apr | 8 | 0 | 30 | 10 | 9 | 0 | 66 | 26 | 27 |
| | United States | *1963* | | | | | | | | | |
| | | Jan | 29 | | | | 10.0 | | | | 26.7 |
| | | Apr | 27 | | | | 4.4 | | | | 13.8 |
| Cereal | | *1963* | | | | | | | | | |
| Corn | | July | 8 | 0 | 50 | 0 | 6 | 0 | 28 | 0 | 6 |
| | | Oct | 7 | 0 | 50 | 0 | 14 | 0 | 48 | 0 | 15 |
| Wheat | | July | 9 | 40 | 250 | 150 | 156 | 13 | 92 | 53 | 59 |
| | | Oct | 11 | 75 | 770 | 250 | 296 | 52 | 164 | 101 | 98 |
| Oats | | July | 4 | 0 | 350 | 175 | 142 | 0 | 95 | 57 | 63 |
| | | Oct | 4 | 200 | 280 | 215 | 228 | 60 | 106 | 79 | 80 |
| Rice | | July | 8 | 0 | 130 | 30 | 38 | 0 | 63 | 35 | 33 |
| | | Oct | 5 | 0 | 120 | 30 | 37 | 0 | 165 | 34 | 56 |
| Wheat, malted | | July | 3 | 110 | 150 | 140 | 133 | 46 | 58 | 47 | 50 |
| | | Oct | 2 | 150 | 240 | 195 | 195 | 98 | 98 | 98 | 98 |
| Bran | | July | 2 | 150 | 490 | 320 | 320 | 28 | 39 | 38 | 38 |
| | | Oct | 4 | 160 | 810 | 277 | 381 | 19 | 80 | 35 | 45 |
| | United States | *1963* | | | | | | | | | |
| | | July | 34 | | | | 99.0 | | | | 36.0 |
| | | Oct | 33 | | | | 193.0 | | | | 61.0 |

# Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4, 5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press (1959).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press (1965).

# NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. Data from the Pasteurized Milk Network (U.S.), Canadian Milk Network, Pan American Milk Network, and the HASL milk program are presented below.

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## 1. Pasteurized Milk Network November 1965

*Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 issue of *Radiological Health Data* (*1*).

The results for November 1965 and third quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples

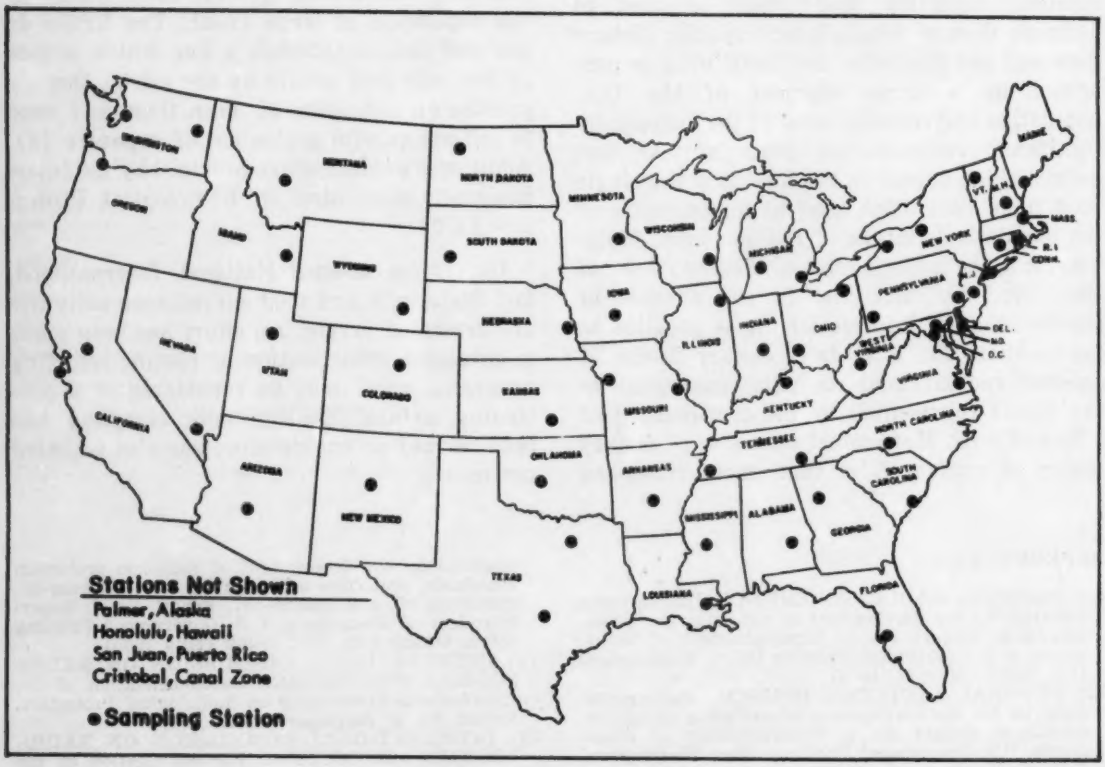


Figure 1. Pasteurized Milk Network sampling locations

**Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the third quarter and November 1965 [a]**

| Sampling locations | | Calcium (g/liter) | | Strontium-89 (pCi/liter) | | Strontium-90 (pCi/liter) | | Cesium-137 (pCi/liter) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Third quarter | Average for November | Third quarter | Average for November | Third quarter | Average for November | Third quarter | Average for November |
| Ala: | Montgomery | 1.14 | 1.16 | <5 | <5 | 14 | 15 | 40 | 30 |
| Alaska: | Palmer | 1.22 | 1.27 | <5 | <5 | 15 | 12 | 50 | 40 |
| Ariz: | Phoenix | 1.22 | 1.26 | <5 | <5 | 4 | 5 | 20 | 15 |
| Ark: | Little Rock | 1.14 | 1.20 | 5 | <5 | 28 | 27 | 50 | 25 |
| Calif: | Sacramento | 1.28 | 1.24 | <5 | <5 | 5 | 5 | 25 | 20 |
| | San Francisco | 1.25 | 1.28 | <5 | <5 | 5 | 4 | 20 | 15 |
| C. Z: | Cristobal | 1.10 | 1.13 | <5 | <5 | 4 | 4 | 30 | 35 |
| Colo: | Denver | 1.28 | 1.27 | 5 | <5 | 14 | 11 | 40 | 20 |
| Conn: | Hartford | 1.09 | 1.12 | <5 | <5 | 13 | 13 | 50 | 40 |
| Del: | Wilmington | 1.11 | 1.14 | <5 | <5 | 15 | 13 | 40 | 35 |
| D. C: | Washington | 1.13 | 1.18 | <5 | <5 | 13 | 14 | 30 | 25 |
| Fla: | Tampa | 1.16 | 1.17 | <5 | <5 | 12 | 16 | 175 | 140 |
| Ga: | Atlanta | 1.14 | 1.17 | <5 | <5 | 20 | 19 | 55 | 45 |
| Hawaii: | Honolulu | 1.16 | 1.16 | <5 | <5 | 6 | 7 | 40 | 40 |
| Idaho: | Idaho Falls | 1.27 | 1.27 | <5 | <5 | 16 | 14 | 50 | 40 |
| Ill: | Chicago | 1.11 | 1.14 | <5 | <5 | 11 | 11 | 35 | 35 |
| Ind: | Indianapolis | 1.11 | 1.17 | <5 | <5 | 12 | 11 | 25 | 25 |
| Iowa: | Des Moines | 1.23 | 1.26 | <5 | <5 | 16 | 16 | 30 | 15 |
| Kans: | Wichita | 1.19 | 1.26 | <5 | <5 | 14 | 13 | 25 | 15 |
| Ky: | Louisville | 1.12 | 1.15 | 5 | <5 | 18 | 16 | 25 | 20 |
| La: | New Orleans | 1.18 | 1.21 | <5 | <5 | 33 | 31 | 60 | 40 |
| Maine: | Portland | 1.11 | 1.13 | 5 | <5 | 20 | 18 | 90 | 65 |
| Md: | Baltimore | 1.11 | 1.17 | <5 | <5 | 15 | 15 | 40 | 30 |
| Mass: | Boston | 1.10 | 1.15 | 5 | <5 | 19 | 16 | 80 | 60 |
| Mich: | Detroit | 1.09 | 1.13 | <5 | <5 | 11 | 11 | 35 | 30 |
| | Grand Rapids | 1.13 | 1.17 | <5 | <5 | 14 | 14 | 45 | 40 |
| Minn: | Minneapolis | 1.28 | 1.26 | 5 | <5 | 23 | 22 | 50 | 40 |
| Miss: | Jackson | 1.18 | 1.22 | <5 | <5 | 25 | 25 | 40 | 25 |
| Mo: | Kansas City | 1.21 | 1.22 | 5 | <5 | 18 | 17 | 25 | 15 |
| | St. Louis | 1.22 | 1.32 | 5 | <5 | 16 | 20 | 25 | 15 |
| Mont: | Helena | 1.27 | 1.26 | 5 | <5 | 18 | 16 | 55 | 40 |
| Nebr: | Omaha | 1.22 | 1.25 | <5 | <5 | 16 | 18 | 30 | 25 |
| Nev: | Las Vegas | 1.20 | 1.21 | <5 | <5 | 5 | 6 | 20 | 20 |
| N. H: | Manchester | 1.11 | 1.14 | <5 | <5 | 21 | 18 | 105 | 65 |
| N. J: | Trenton | 1.09 | 1.14 | <5 | <5 | 14 | 11 | 40 | 25 |
| N. Mex: | Albuquerque | 1.24 | 1.22 | <5 | <5 | 6 | 6 | 20 | 10 |
| N. Y: | Buffalo | 1.09 | 1.10 | <5 | <5 | 11 | 12 | 45 | 45 |
| | New York | 1.09 | 1.10 | <5 | <5 | 17 | 14 | 55 | 35 |
| | Syracuse | 1.09 | 1.10 | 5 | <5 | 12 | 12 | 40 | 40 |
| N. C: | Charlotte | 1.13 | 1.17 | <5 | <5 | 24 | 27 | 40 | 25 |
| N. Dak: | Minot | 1.28 | 1.26 | 10 | <5 | 31 | 30 | 55 | 40 |
| Ohio: | Cincinnati | 1.11 | 1.13 | <5 | <5 | 13 | 13 | 25 | 20 |
| | Cleveland | 1.10 | 1.15 | 5 | <5 | 13 | 12 | 35 | 25 |
| Okla: | Oklahoma City | 1.11 | 1.18 | <5 | <5 | 14 | 14 | 25 | 20 |
| Ore: | Portland | 1.28 | 1.27 | <5 | <5 | 14 | 13 | 50 | 45 |
| Pa: | Philadelphia | 1.08 | 1.10 | <5 | <5 | 13 | 11 | 35 | 30 |
| | Pittsburgh | 1.11 | 1.14 | 5 | <5 | 20 | 18 | 50 | 35 |
| P. R: | San Juan | 1.13 | 1.10 | <5 | <5 | 9 | 9 | 40 | 25 |
| R. I: | Providence | 1.10 | 1.15 | <5 | <5 | 16 | 15 | 65 | 40 |
| S. C: | Charleston | 1.14 | 1.19 | <5 | <5 | 23 | 27 | 70 | 55 |
| S. Dak: | Rapid City | 1.04 | 1.18 | 10 | <5 | 20 | 22 | 50 | 45 |
| Tenn: | Chattanooga | 1.16 | 1.24 | <5 | <5 | 26 | 22 | 40 | 30 |
| | Memphis | 1.15 | 1.17 | 5 | <5 | 20 | 18 | 25 | 20 |
| Tex: | Austin | 1.12 | 1.15 | <5 | <5 | 5 | 6 | 20 | 10 |
| | Dallas | 1.11 | 1.15 | <5 | <5 | 12 | 13 | 25 | 20 |
| Utah: | Salt Lake City | 1.36 | 1.36 | <5 | <5 | 12 | 11 | 55 | 35 |
| Vt: | Burlington | 1.11 | 1.09 | <5 | <5 | 17 | 14 | 65 | 55 |
| Va: | Norfolk | 1.13 | 1.16 | <5 | <5 | 17 | 17 | 40 | 25 |
| Wash: | Seattle | 1.28 | 1.28 | <5 | <5 | 18 | 17 | 70 | 45 |
| | Spokane | 1.33 | 1.28 | <5 | <5 | 18 | 17 | 50 | 40 |
| W. Va: | Charleston | 1.12 | 1.14 | <5 | <5 | 18 | 16 | 25 | 20 |
| Wis: | Milwaukee | 1.17 | 1.18 | <5 | <5 | 11 | 11 | 40 | 40 |
| Wyo: | Laramie | 1.28 | 1.23 | <5 | <5 | 14 | 25 | 50 | 40 |
| Network average | | 1.16 | 1.19 | <5 | <5 | 15.3 | 15.0 | 44 | 34 |

[a] All iodine-131 and barium-lanthanum-140 values were below detectable levels.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network Stations, June–November 1965 and November 1964

| Strontium-90 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | | 1964 |
| | June | July | Aug | Sep | Oct | Nov | Nov |
| Under 10 | 7 | 8 | 10 | 11 | 8 | 9 | 6 |
| 10–19 | 21 | 34 | 41 | 44 | 46 | 43 | 31 |
| 20–29 | 29 | 18 | 11 | 7 | 7 | 9 | 19 |
| 30–39 | 4 | 3 | 1 | 1 | 2 | 2 | 6 |
| 40–49 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| 50–59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, June–November 1965 and November 1964

| Cesium-137 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | | 1964 |
| | June | July | Aug | Sep | Oct | Nov | Nov |
| Under 50 | 19 | 34 | 45 | 50 | 54 | 57 | 15 |
| 50–99 | 38 | 25 | 16 | 12 | 8 | 5 | 41 |
| 100–149 | 5 | 3 | 1 | 0 | 0 | 1 | 4 |
| 150–199 | 1 | 1 | 1 | 1 | 1 | 0 | 2 |
| 200–249 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 250–299 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for June through November 1965 and November 1964. The average strontium–90 concentrations in pasteurized milk from selected cities of the network are plotted in figure 2.

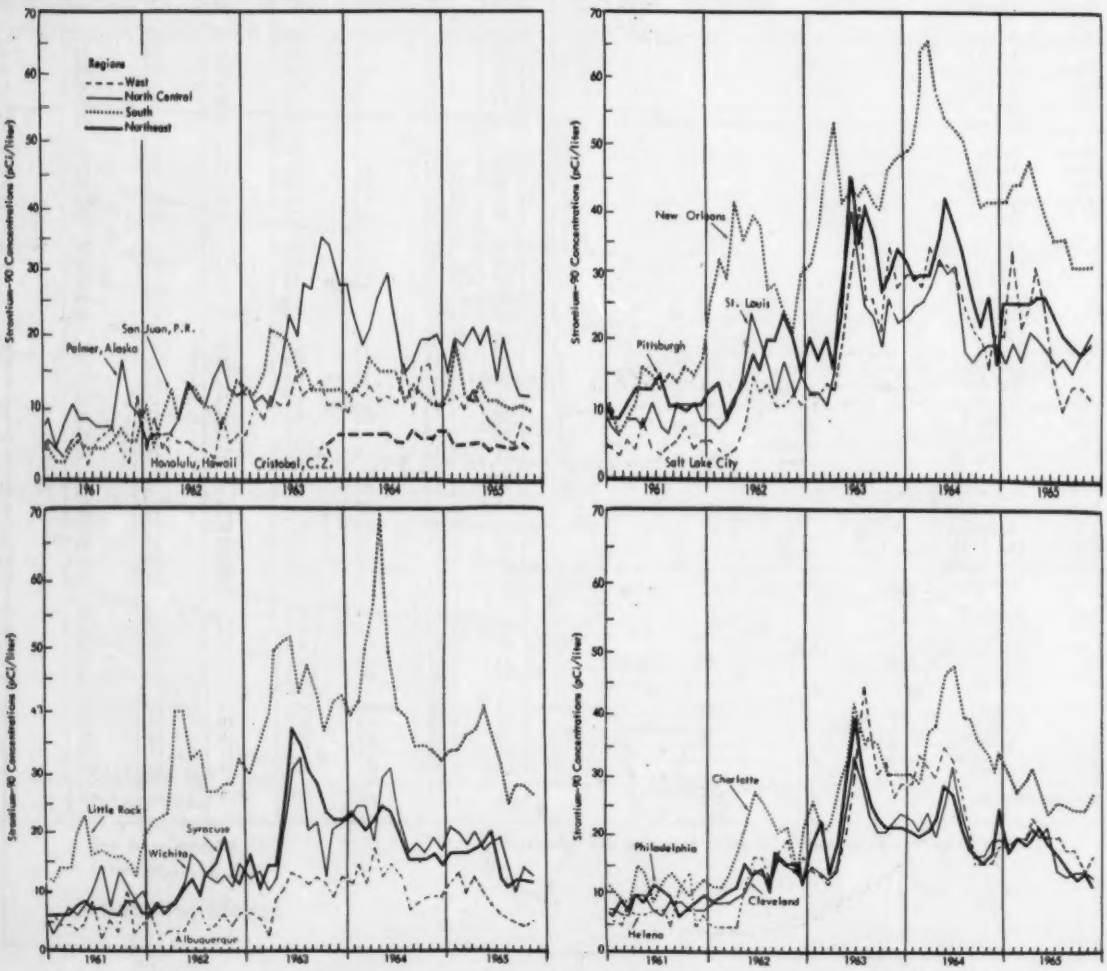


Figure 2. Strontium–90 concentrations in pasteurized milk, 1961–November 1965

## 2. Canadian Milk Network November 1965 [1]

*Radiation Protection Division*
*Department of National Health and Welfare,*
*Ottawa, Canada*

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*2*).

The November 1965 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

**Table 4. Stable elements and radionuclides in Canadian whole milk, November 1965**

| Station | Calcium (g/liter) | Potassium (g/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|
| Calgary | 1.13 | 1.6 | 20.2 | 60 |
| Edmonton | 1.12 | 1.6 | 18.3 | 58 |
| Ft. William | 1.11 | 1.6 | 33.4 | 79 |
| Fredericton | 1.14 | 1.6 | 26.8 | 80 |
| Halifax | 1.11 | 1.6 | 24.6 | 71 |
| Montreal | NA | 1.6 | NA | 41 |
| Ottawa | 1.14 | 1.6 | 14.9 | 38 |
| Quebec | 1.11 | 1.6 | 25.6 | 76 |
| Regina | 1.14 | 1.6 | 15.7 | 38 |
| St. John's, Nfld | 1.03 | 1.4 | 21.0 | 84 |
| Saskatoon | 1.15 | 1.6 | 20.0 | 37 |
| Sault Ste. Marie | 1.03 | 1.6 | 26.5 | 74 |
| Toronto | 1.15 | 1.6 | 7.2 | 32 |
| Vancouver | 1.19 | 1.5 | 22.5 | 100 |
| Windsor | 1.15 | 1.5 | 10.4 | 22 |
| Winnipeg | 1.06 | 1.5 | 18.7 | 57 |
| Average | 1.12 | 1.6 | 20.3 | 59 |

NA, no analysis

[1] Prepared from December 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

**Figure 3. Canadian milk sampling stations**

## 3. Pan American Milk Sampling Program November 1965

*Pan American Health Organization and Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*3*).

**Figure 4. Pan American Milk Network sampling locations**

Table 5 presents stable calcium and potassium, strontium–90, strontium–89, and cesium–137 monthly average concentrations. The monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

**Table 5. Stable element and radionuclide concentrations in PAHO milk, November 1965**

| Sampling station | Calcium (g/liter) | Potassium (g/liter) | Strontium-89 (pCi/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|---|
| Canal Zone: | | | | | |
| Cristobal[1] | 1.13 | 1.4 | <5 | 4 | 35 |
| Jamaica: | | | | | |
| Kingston | NS | NS | NS | NS | NS |
| Mandeville | 1.09 | 1.31 | <5 | 9 | 180 |
| Montego Bay | NS | NS | NS | NS | NS |
| Puerto Rico: | | | | | |
| San Juan | 1.10 | 1.5 | <5 | 9 | 25 |
| Venezuela: | | | | | |
| Caracas | 1.19 | 1.35 | <5 | 4 | 10 |

NS, no sample collected.

## 4. Radiostrontium in milk April–June 1965[2]

*Health and Safety Laboratory U.S. Atomic Energy Commission*

In 1954, the Health and Safety Laboratory began monitoring strontium–90 in liquid whole milk in New York City to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York (1954), and at Mandan, North Dakota (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected

[2] Data summarized from "Fallout Program Quarterly Summary Report, HASL–165," available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is a herd on the island of Oahu where the cows are on pasture throughout the year.

## *Results*

The calcium and strontium-90 concentrations in liquid whole milk are given in table 6, and presented graphically in figure 5. Strontium-90 and calcium results for powdered milk and powdered buttermilk are shown in tables 7 and 8. The strontium-90 results for powdered milk and buttermilk are shown in figure 6.

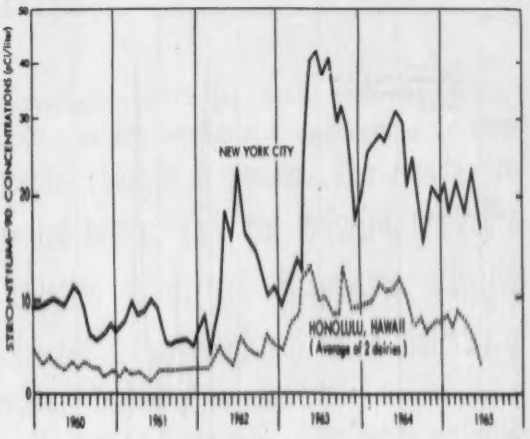


**Figure 5. Strontium-90 in liquid milk samples, Honolulu, Hawaii, and New York City, 1960–June 1965**

**Table 6. Strontium-90 and calcium in liquid milk, January–June 1965, and annual average strontium-90 concentrations in milk, 1959–1964**

| Sampling station and periods | Calcium concentration (g/liter) | Strontium-90 concentration (pCi/liter) | Strontium-90/ calcium ratio (pCi/g) |
|---|---|---|---|
| New York City | | | |
| 1959 average | | | 11 |
| 1960 average | | | 8.0 |
| 1961 average | | | 6.7 |
| 1962 average | | | 12 |
| 1963 average | | | 26 |
| 1964 average | | | 23 |
| 1965 | | | |
| January | 1.03 | 21.4 | 20.8 |
| February | 1.02 | 18.4 | 18.0 |
| March | 1.01 | 21.4 | 21.1 |
| April | 1.04 | 19.8 | 19.0 |
| May | 1.02 | 23.3 | 22.9 |
| June | 1.15 | 20.7 | 18.0 |
| Honolulu, Hawaii | | | |
| 1959 average | | | 5.0 |
| 1960 average | | | 3.2 |
| 1961 average | | | 2.4 |
| 1962 average | | | 4.3 |
| 1963 average | | | 8.0 |
| 1964 average | | | 8.6 |
| 1965 | | | |
| January | 1.04 | 8.2 | 7.9 |
| February | 1.02 | 7.8 | 7.6 |
| March | 1.00 | 8.8 | 8.9 |
| April | 1.03 | 7.8 | 7.6 |
| May | 1.07 | 7.2 | 6.8 |
| June | 1.19 | 5.4 | 4.6 |

**Table 7. Strontium-90 and calcium in powdered milk, January–June 1965, and annual average strontium-90 concentrations in powdered milk, 1959–1964**

| Sampling station and month | Calcium concentration (g/kg) | Strontium-90 concentration (pCi/kg) | Strontium-90/ calcium ratio (pCi/g) |
|---|---|---|---|
| Perry, New York | | | |
| 1959 average | | | 8.0 |
| 1960 average | | | 6.5 |
| 1961 average | | | 6.2 |
| 1962 average | | | 11.1 |
| 1963 average | | | 21.6 |
| 1964 average | | | 20.4 |
| 1965 | | | |
| January | 9.33 | 166 | 17.7 |
| February | 8.51 | 121 | 14.2 |
| March | 8.73 | 166 | 19.0 |
| April | 8.58 | 157 | 18.3 |
| May | 8.72 | 148 | 16.9 |
| June | 10.0 | 134 | 13.3 |

**Table 8. Strontium-90 and calcium in powdered buttermilk, January–June 1965, and annual average strontium-90/ calcium ratios in buttermilk, 1959–1964**

| Sampling station and month | Calcium concentration (g/kg) | Strontium-90 concentration (pCi/kg) | Strontium-90/ calcium ratio (pCi/g) |
|---|---|---|---|
| Mandan, North Dakota | | | |
| 1959 average | | | 26 |
| 1960 average | | | 15 |
| 1961 average | | | 9.4 |
| 1962 average | | | 25 |
| 1963 average | | | 58 |
| 1964 average | | | 62.7 |
| 1965 | | | |
| January | 10.8 | 594 | 54.6 |
| February | 10.4 | 522 | 50.0 |
| March | 10.8 | 699 | 61.8 |
| April | 11.2 | 680 | 60.7 |
| May | 8.9 | 588 | 66.3 |
| June | 12.7 | 411 | 32.4 |

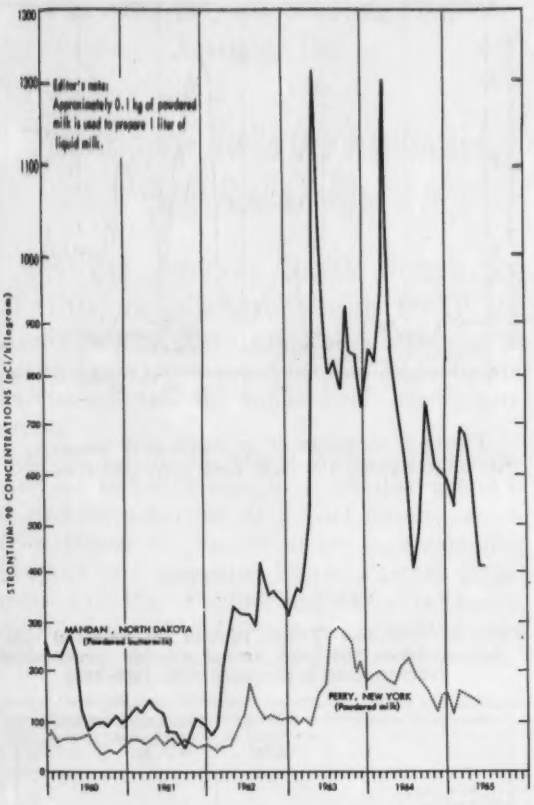


**Figure 6. Strontium–90 in powdered milk samples, Perry, New York, and Mandan, North Dakota 1960–June 1965**

## REFERENCES


(*1*) U.S. PUBLIC HEALTH SERVICE. Milk surveillance, Pasteurized Milk Network, August 1965. Rad Health Data 6:677–681 (December 1965).

(*2*) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).


Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| April–June 1963 | *January 1964* |
| July–September 1963 | *April 1964* |
| October–December 1963 | *July 1964* |
| January–December 1964 | *June 1965* |
| January–March 1965 | *September 1965* |

# STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to a state of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at present. The results presented herein, while not inclusive, are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Reports of State milk surveillance activities appeared in the following previous issues of *Radiological Health Data and Reports:*

| Program | Period reported | Last presented |
|---|---|---|
| Colorado Milk Network | October–December 1964 | April 1965 |
| Connecticut Milk Network | April–September 1965 | February 1966 |
| Florida Milk Network | January–June 1965 | January 1966 |
| Indiana Milk Network | July–September 1965 | February 1966 |
| Michigan Milk Network | July–September 1965 | February 1966 |
| Minnesota Milk Network | January–June 1965 | January 1966 |
| New York Milk Network | April–June 1965 | January 1966 |
| Oklahoma Milk Network | March–July 1965 | October 1965 |
| Pennsylvania Milk Network | July–September 1965 | February 1966 |
| Texas Milk Network | January–March 1965 | October 1965 |

## 1. California Milk Network July–September 1965

*Division of Environmental Sanitation*
*State of California*
*Department of Public Health*

Surveillance of specific radionuclides in milk is one phase of California's Department of Health program of radiation control. This milk monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

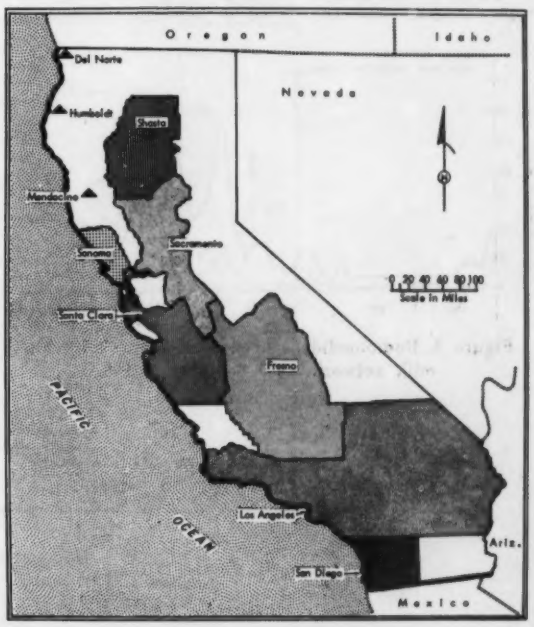


Figure 1. California milksheds

Strontium–89 and strontium–90 concentrations are determined radiochemically. Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented earlier (*2*).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period July to September 1965.

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 2. Superimposed upon normal seasonal variations is a decreasing trend since the peak which occurred in the spring of 1963.

**Table 1. Stable elements and radionuclides in California milk, July-September 1965**

| Element and month | Del Norte | Fresno | Humboldt | Los Angeles | Mendocino | Sacramento | San Diego | Santa Clara | Shasta | Sonoma | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Calcium (g/liter) | | | | | | | | | | | |
| July | 1.37 | 1.16 | 1.23 | 1.11 | 1.20 | 1.00 | 1.12 | 1.15 | 1.10 | 1.31 | 1.17 |
| August | 1.38 | 1.23 | 1.21 | 1.10 | 1.15 | 1.17 | 1.11 | 1.12 | 1.12 | 1.20 | 1.18 |
| September | 1.27 | 1.25 | 1.31 | 1.14 | 1.28 | 1.26 | 1.15 | 1.16 | 1.21 | 1.27 | 1.23 |
| Potassium-40 (pCi/liter) | | | | | | | | | | | |
| July | 1,132 | 1,110 | 1,158 | 1,201 | 1,319 | 1,133 | 1,250 | 1,158 | 1,237 | 1,260 | 1,196 |
| August | 1,189 | 1,157 | 1,157 | NA | 1,351 | 1,262 | 1,230 | 1,161 | 1,177 | 1,237 | 1,213 |
| September | 1,089 | 1,212 | 1,183 | 1,203 | 1,281 | 1,232 | 1,212 | 1,200 | 1,157 | 1,257 | 1,002 |
| Strontium-89 (pCi/liter) | | | | | | | | | | | |
| July | *2.3 | NA | 1.5 | NA | NA | *0.9 | ND | *2.1 | ND | ND | 0.9 |
| August | 0.9 | ND | ND | *0.14 | ND | *2.4 | 1.1 | *0.9 | ND | *0.3 | 0.4 |
| September | 1.6 | ND | ND | 0.2 | ND | *1.0 | ND | ND | 0.7 | ND | 0.3 |
| Strontium-90 (pCi/liter) | | | | | | | | | | | |
| July | 33 | 5.3 | 8.7 | 3.6 | 6.7 | 3.9 | 2.9 | 3.4 | 0.8 | 7.9 | 7.6 |
| August | 22 | 3.7 | 10. | 2.4 | 5.3 | 3.5 | 1.7 | 5.0 | 0.8 | 6.2 | 6.1 |
| September | 14 | 2.9 | 6.4 | 2.7 | 4.4 | 3.9 | 2.6 | 2.8 | 0.5 | 4.7 | 4.5 |
| Cesium-137 (pCi/liter) | | | | | | | | | | | |
| July | 47 | 14 | 11 | 20 | 14 | 18 | 17 | 24 | 23 | 33 | 22 |
| August | 40 | 17 | 19 | NA | 22 | 21 | *13 | 22 | 27 | 33 | 24 |
| September | 23 | 17 | 12 | 20 | 18 | 21 | 18 | 15 | 28 | 24 | 20 |

NA, No analysis performed.
ND, Below detectable level.
* When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant. Where no value is given, no activity was detected.

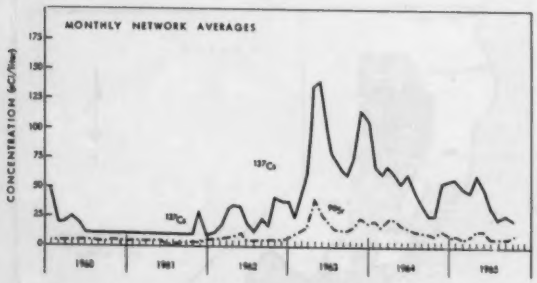


**Figure 2. Radionuclide concentrations in California milk network, 1960–September 1965**

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| July–September 1963 | *March 1964* |
| October–December 1963 | *June 1964* |
| January–March 1964 | *September 1964* |
| April–June 1964 | *December 1964* |
| July–September 1964 | *March 1965* |
| October–December 1964 | *June 1965* |
| January–March 1965 | *September 1965* |
| April–June 1965 | *December 1965* |

## 2. Oregon Milk Network July–September 1965 [1]

*Division of Sanitation and Engineering*
*Oregon State Board of Health*

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at eight major production areas (figure 3), which supply 90 percent of the milk distributed in the State. Currently, pasteurized milk samples are collected monthly except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine–131 concentrations exceed 100 pCi/liter, or where cesium–137 concentrations exceed 500 pCi/liter. Strontium–90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

[1] This work was summarized under the supervision of George L. Toombs, chief radiochemist, Oregon State Board of Health.

Strontium–90 concentrations are determined using a trichloracetic acid analytical procedure (*3*). Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 2 gives the strontium–90 and cesium–137 concentration in pasteurized milk from July through September 1965. These data are presented graphically in figure 4. Iodine–131 and barium–140 concentrations remained below minimum detectable levels.

**Table 2. Radionuclide concentrations in Oregon milk, July–September 1965 (pCi/liter)**

| Sampling locations | Sampling frequency | Strontium-90 | | | Cesium-137 | | |
|---|---|---|---|---|---|---|---|
| | | July | Aug | Sep | July | Aug | Sep |
| Baker | M | 16 | NA | 11 | 65 | 60 | 40 |
| Coos Bay | M | 25 | NA | 12 | 75 | 60 | 35 |
| Eugene | M | 10 | NA | 11 | 35 | 30 | 35 |
| Medford | M | 11 | NA | 11 | 85 | 35 | 30 |
| Nyssa | M | 17 | NA | 19 | 60 | 50 | 30 |
| Portland composite | W | 15 | 13 | 16 | 55 | 45 | 50 |
| Portland local | W | 24 | NA | 15 | 65 | 70 | 50 |
| Redmond | M | 13 | NA | 10 | 50 | 60 | 60 |
| Tillamook | M | 38 | NA | 26 | 105 | 65 | 80 |
| Average | — | 19 | 13 | 15 | 66 | 55 | 40 |

Key to symbols: M, sampled monthly
W, sampled weekly
NA, no analysis

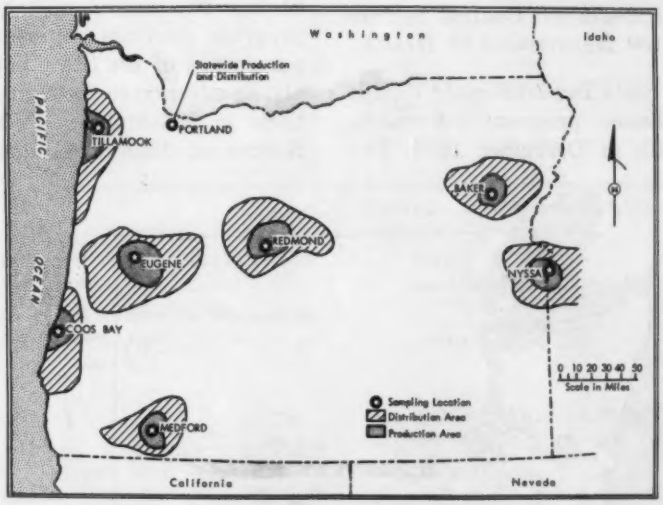


**Figure 3. Oregon milksheds**

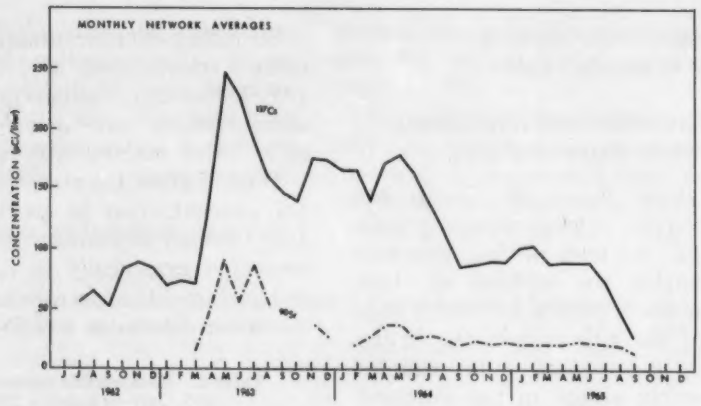
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
250
200
150
100
50
0
J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1962
1963
1964
1965

**Figure 4. Radionuclide concentrations in Oregon milk network, 1962–September 1965**

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| October–December 1964 and Summary 1962–1964 | *June 1965* |
| January–March 1965 | *August 1965* |
| April–June 1965 | *December 1965* |

## 3. Washington Milk Network July–September 1965

*Air Sanitation and Radiation Control Section*
*State of Washington Department of Health*

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. This sampling program provides representation for a large percentage of the State population's milk supply. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area

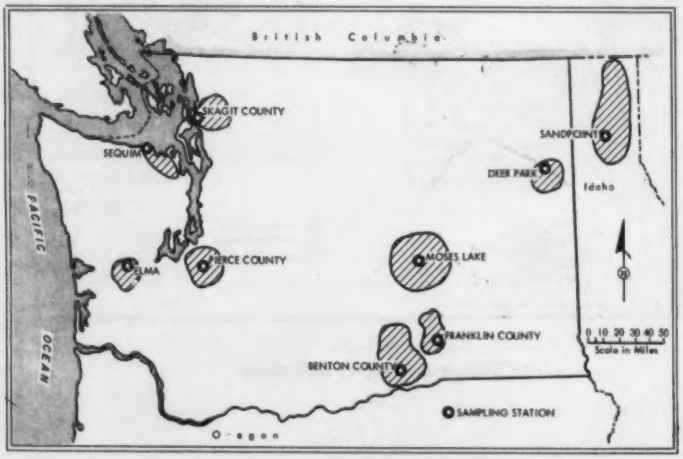


**Figure 5. Washington milkshed production areas**

forms a part of the Spokane milkshed. Details of the sampling procedures were presented earlier (*5*).

Selected samples are radiochemically analyzed for strontium–90. Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for July through September 1965. During this period iodine–131 and barium–140 concentrations remained below minimum detectable levels. Monthly average strontium–90 and cesium–137 concentrations are presented graphically in figure 6, so as to display general trends.

Zinc–65 was observed in Franklin County on two occasions during this period (table 4). This nuclide has periodically appeared in this county as a result of the irrigation of some pasture land with Columbia River water which has been shown to contain this contaminant.

**Table 3. Radionuclide concentrations (pCi/liter) in Washington milk, July–September 1965**

| Sampling locations | Potassium-40 | | | Strontium-90 | | | Cesium-137 | | |
|---|---|---|---|---|---|---|---|---|---|
| | July | Aug | Sept | July | Aug | Sept | July | Aug | Sept |
| Benton County | NS | 1,184 | NS | NS | 7 | NS | NS | 30 | NS |
| Deer Park | 1,250 | 1,214 | 1,232 | 15 | 14 | 12 | 53 | 63 | 49 |
| Elma | 1,365 | 1,192 | 1,156 | 12 | 15 | 11 | 87 | 75 | 80 |
| Franklin County | 1,326 | NS | 1,250 | 6 | NS | 8 | 24 | NS | 28 |
| Moses Lake | 1,280 | 1,261 | 1,252 | 21 | 8 | 6 | 45 | 33 | 26 |
| Pierce County | 1,155 | 1,367 | 1,347 | 17 | 21 | 15 | 136 | 114 | 70 |
| Sandpoint | 1,303 | 1,369 | 1,198 | 31 | 30 | 25 | 138 | 160 | 106 |
| Sequim | 1,133 | 1,324 | 1,103 | 11 | 10 | 10 | 49 | 50 | 30 |
| Skagit County | 1,170 | 1,151 | 1,155 | 8 | 18 | 16 | 82 | 72 | 61 |
| Average | 1,248 | 1,258 | 1,212 | 15 | 15 | 13 | 77 | 75 | 56 |

NS, no sample collected

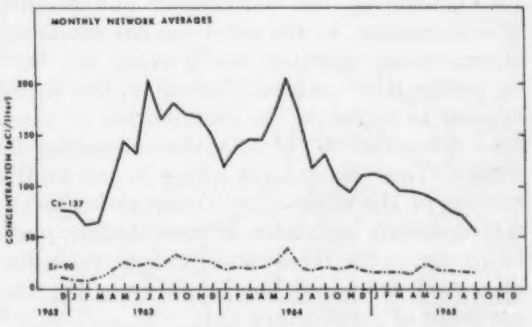


**Figure 6. Radionucilde concentrations in Washington milk 1962–September 1965**

**Table 4. Milk samples in Franklin County, Washington, containing zinc-65**

| Sampling location | Date (1965) | Zinc-65 (pCi/liter) |
|---|---|---|
| Franklin County | July 14 | 74 |
| Franklin County | September 8 | 258 |

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| December 1962–December 1963 | *May 1964* |
| January–June 1964 | *February 1965* |
| July–December 1964 | *May 1965* |
| January–June 1965 | *November 1965* |

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(*1*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California Milk Network, 1960–June 1962. Rad Health Data 4:90–92 (February 1963).

(*2*) HESLEP, J. M., and A. C. CORNISH. California Milk Network and milkshed comparisons, April–June 1963. Rad Health Data 4:596–599 (December 1963).

(*3*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Dairy Sci 43:151–154 (1960).

(*4*) DIVISION OF SANITATION AND ENGINEERING, OREGON STATE BOARD OF HEALTH. Oregon Milk Network, April–June 1965. Rad Health Data 6:683–684 (December 1965).

(*5*) AIR AND RADIATION CONTROL SECTION, STATE OF WASHINGTON DEPARTMENT OF HEALTH. Washington Milk Network, January–June 1965. Rad Health Data 6:619–621 (November 1965).

# FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides.

Other diet programs previously covered in *Radiological Health Data and Reports* are listed below.

| Program | Period reported | Last presented |
|---|---|---|
| Institutional Total Diet | April–June 1965 | February 1966 |
| Tri-City Diet | February–April 1965 | December 1965 |
| Teenage Diet | February–November 1964 | July 1965 |
| California Diet | November–December 1964 | December 1965 |
| Connecticut Standard Diet | March 1963–December 1964 | July 1965 |

## 1. Strontium–90 in Tri-City Diets May–July 1965 [1]

*Health and Safety Laboratory*
*U.S. Atomic Energy Commission*

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium–90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium–90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium–90 over the last 4 years has been approximately 5 percent. Therefore, this figure is used to calculate the contribution of these food categories to the total diet strontium–90 intake. These values are added to the contributions of the other 14 food categories to obtain quarterly estimates of annual strontium–90 intake at the three cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

[1] Data from Fallout Program Quarterly Summary Report, HASL–165 January 1, 1966. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of results obtained have been summarized (*3*).

Results of the May to July 1965 sampling are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1.

**Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, May–July 1965**

| Food category | Diet (kg/yr) | Calcium (g/yr) | New York City—May 1965 | | Chicago—July 1965 | | San Francisco—June 1965 | |
|---|---|---|---|---|---|---|---|---|
| | | | (pCi/kg) | (pCi/yr) | (pCi/kg) | (pCi/yr) | (pCi/kg) | (pCi/yr) |
| Bakery products | 37 | 37.0 | 27.4±1.0 | 1,014 | 22.2±1.2 | 821 | 12.4±1.0 | 459 |
| Whole grain products | 11 | 10.0 | 48.0±1.3 | 528 | 46.2±1.7 | 508 | 22.9±2.0 | 252 |
| Fresh vegetables | 43 | 15.0 | 17.4±0.4 | 748 | 7.9±0.3 | 340 | 3.0±0.3 | 129 |
| Root vegetables | 17 | 6.1 | 11.4±0.5 | 194 | 4.7±0.4 | 80 | 3.8±0.2 | 65 |
| Milk | 221 | 234.4 | 22.6±0.4 | 4,995 | 9.2±0.3 | 2,033 | 11.4±0.4 | 2,519 |
| Flour | 43 | 8.6 | 22.6±0.4 | 972 | 17.9±0.3 | 770 | 4.5±0.2 | 194 |
| Macaroni | 3 | 0.7 | 14.9±0.7 | 45 | 14.4±0.5 | 43 | 9.6±0.5 | 29 |
| Rice | 3 | 1.1 | 2.2±0.2 | 7 | 3.6±0.3 | 11 | 3.2±0.3 | 10 |
| Dried beans | 3 | 2.9 | 35.0±1.8 | 105 | 18.8±1.8 | 56 | 12.8±0.2 | 38 |
| Fresh fruit | 68 | 12.6 | 8.5±0.4 | 578 | 2.3±0.2 | 156 | 3.8±0.3 | 258 |
| Potatoes | 45 | 5.8 | 9.7±0.5 | 436 | 2.4±0.5 | 108 | 1.6±0.4 | 72 |
| Canned fruit | 26 | 1.3 | 3.9±0.2 | 101 | 4.0±0.1 | 104 | 2.0±0.1 | 52 |
| Fruit juices | 19 | 1.7 | 6.7±0.4 | 127 | 6.8±0.3 | 129 | 2.9±0.2 | 55 |
| Canned vegetables | 20 | 4.2 | 25.0±0.7 | 500 | 11.1±0.5 | 222 | 3.0±0.5 | 60 |
| Meat, fish, poultry, shellfish, and eggs | 99 | 42.0 | | • 545 | | • 280 | | • 221 |
| Annual intake | — | 383.0 | — | 10,895 | — | 5,664 | — | 4,413 |
| pCi strontium-90/g Ca | | | | 28.4 | | 14.8 | | 11.5 |

• Estimated as 5 percent of total intake.

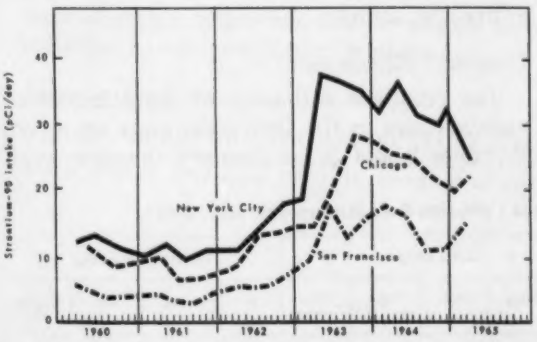


**Figure 1. Daily intake of strontium–90 in Tri-City diet 1960–July 1965**

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| Sixteenth Sampling (February–April 1964) | *December 1964* |
| Seventeenth Sampling (May–July 1964) | *March 1965* |
| Eighteenth Sampling (August–October 1964) | *June 1965* |
| Nineteenth Sampling (November 1964–January 1965) | *September 1965* |

## 2. Estimated daily intake of radionuclides in California diets January–April 1965 [1]

*Bureau of Radiological Health*
*California State Department of Public Health*

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*4*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

*Sampling procedure*

In general, the sampling procedure is the same at each hospital. Samples are collected once every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

*Analytical procedures*

After weighing at the Laboratory, each sample is homogenized, dried, and ashed prior to stable calcium, potassium, strontium, and sodium determinations being made.

The radiochemical analyses are based upon three basic procedures: chemical separations of strontium–89 and strontium–90; analysis of radium–226; and gamma spectrometry of the entire wet sample.

*Data and discussion*

The resultant estimates of daily intake of radionuclides in the California diets are given in tables 2 and 3 for January through April

[1] This work was summarized under the supervision of Amasa C. Cornish, senior health physicist, Jack L. Brown, associate health physicist, and George Barr, radiological health specialist, Bureau of Radiological Health, California State Department of Public Health.

**Table 2. Estimated daily intake of radionuclides in California diets January–February, 1965 [a]**

| City | Kg/capita per day [b] | pCi/capita • day | | | | | Grams/capita • day | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $^{90}Sr$ | $^{226}Ra$ | $^{137}Cs$ | $^{95}Zr$ | $^{141}Ce$ $^{144}Ce$ | K [c] | Na | Ca | Stable Sr |
| Bakersfield | 1.5 | 7 | 0.2 | 32 | 0 | 0 | 1.9 | 2.3 | 0.7 | 0.001 |
| Berkeley | 2.9 | 22 | 0.6 | 85 | 0 | 0 | 4.4 | 5.9 | 1.3 | 0.001 |
| Bishop | 1.8 | 15 | 0.2 | 96 | 11 | 0 | 2.3 | 2.9 | 0.6 | 0.003 |
| Brawley | 2.3 | 19 | 1.3 | 57 | 23 | 0 | 3.2 | 3.9 | 1.3 | 0.001 |
| Crescent City | 2.2 | 46 | 0.6 | 150 | 11 | 42 | 2.7 | 4.0 | 0.9 | 0.001 |
| Eureka | 2.1 | 22 | 0.6 | 87 | 0 | 0 | 2.5 | 2.5 | 1.2 | 0.001 |
| Fresno | 2.5 | 14 | 1.0 | 8 | 0 | 5 | 3.5 | 5.3 | 0.9 | 0 |
| Los Angeles | 1.3 | 6 | 0.2 | 46 | 0 | 15 | 1.9 | 2.4 | 0.7 | 0.001 |
| Needles | 2.3 | 10 | 0.7 | 66 | 0 | 0 | 2.5 | 4.0 | 1.0 | 0.001 |
| Quincy | 1.3 | 9 | 0.3 | 49 | 0 | 0 | 2.1 | 2.6 | 0.3 | 0.001 |
| Redding | 2.1 | 11 | 0.3 | 72 | 0 | 3 | 3.0 | 5.0 | 0.7 | 0.001 |
| Sacramento | 2.7 | 12 | 0.9 | 73 | 10 | 0 | 2.3 | 4.5 | 0.9 | 0.001 |
| Salinas | 2.4 | 10 | 0.8 | 60 | 2 | 0 | 2.9 | 4.7 | 0.8 | 0.001 |
| San Bernardino | 2.2 | 13 | 0.3 | 60 | 6 | 0 | 2.8 | 4.0 | 1.2 | 0.001 |
| San Diego | 2.2 | 8 | 0.9 | 54 | 0 | 0 | 2.7 | 3.3 | 0.9 | 0.001 |
| San Luis Obispo [d] | | | | | | | | | | |
| Santa Barbara | 2.4 | 17 | 0.9 | 75 | 2 | 0 | 3.2 | 4.4 | 1.1 | 0.003 |
| Santa Rosa | 2.4 | 13 | 0.6 | 114 | 2 | 0 | 3.0 | 3.3 | 1.2 | 0 |
| Susanville | 2.2 | 9 | 0.2 | 75 | 0 | 24 | 2.3 | 6.0 | 0.8 | 0.001 |
| Ukiah | 2.1 | 24 | 1.0 | 47 | 0 | 0 | 2.8 | 2.8 | 2.0 | 0 |

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 and manganese-54 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Sample lost or unsatisfactory.

**Table 3. Estimated daily intake of radionuclides in California diets, March–April 1965 [a]**

| City | Kg/capita per day [b] | pCi/capita • day | | | | | | Grams/capita • day | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $^{90}Sr$ | $^{226}Ra$ | $^{137}Cs$ | $^{95}Zr$ | $^{54}Mn$ | $^{141}Ce$ $^{144}Ce$ | K [c] | Na | Ca | Stable Sr |
| Bakersfield | 2.2 | 12 | 0.5 | 58 | 10 | 0 | 0 | 2.7 | 3.3 | 2.2 | 0.001 |
| Berkeley | 2.4 | 12 | 0.3 | 54 | 0 | 0 | 0 | 2.4 | 4.2 | 0.7 | 0.005 |
| Bishop | 1.6 | 10 | 0.4 | 65 | 9 | 0.3 | 9.0 | 1.8 | 2.7 | 0.5 | 0 |
| Brawley | 2.8 | 12 | 1.0 | 58 | 15 | 0 | 0 | 3.5 | 4.5 | 1.1 | 0.001 |
| Crescent City | 2.3 | 28 | 0.2 | 121 | 14 | 0 | 0 | 2.5 | 4.6 | 2.1 | 0.001 |
| Eureka | 2.4 | 29 | 0.2 | 122 | 39 | 0 | 0 | 3.0 | 3.0 | 1.2 | 0.007 |
| Fresno | 2.3 | 11 | 0.7 | 63 | 13 | 0.1 | 0.4 | 2.3 | 4.0 | 0.8 | 0.002 |
| Los Angeles | 2.0 | 6 | 0.1 | 60 | 2 | 0 | 0 | 1.8 | 2.4 | 0.5 | 0.005 |
| Needles | 2.4 | 13 | 0.2 | 66 | 5 | 0 | 0 | 2.2 | 3.2 | 2.1 | 0.001 |
| Quincy | 2.0 | 16 | 0.2 | 90 | 10 | 3.3 | 0 | 2.8 | 3.6 | 2.1 | 0.001 |
| Redding | 2.1 | 25 | 1.1 | 65 | 9 | 0 | 3.4 | NA | NA | 1.0 | 0.002 |
| Sacramento | 2.9 | 2 | 0.6 | 83 | 0 | 4.2 | 11.0 | 2.9 | 6.0 | 1.3 | 0 |
| Salinas | 2.5 | 13 | 0.2 | 70 | 5 | 0.3 | 5.8 | 2.7 | 5.1 | 2.0 | 0.001 |
| San Bernardino | 2.1 | 9 | 0.6 | 47 | 8 | 1.6 | 5.8 | 2.4 | 3.5 | 1.0 | 0.001 |
| San Diego | 2.0 | 12 | 0.4 | 58 | 2 | 0 | 0 | 2.9 | 3.1 | 2.0 | 0.005 |
| San Luis Obispo | 1.4 | 8 | 0.2 | 43 | 0 | 0 | 0 | 1.8 | 3.0 | 1.0 | 0.001 |
| Santa Barbara | 1.6 | 14 | 0.6 | 60 | 1 | 0 | 0.6 | 2.2 | 3.0 | 1.0 | 0.001 |
| Santa Rosa | 2.5 | 25 | 0.6 | 94 | 5 | 0 | 2.9 | 2.8 | 3.1 | 1.3 | 0 |
| Susanville | 2.1 | 16 | 0.4 | 104 | 6 | 0 | 0 | 2.6 | 4.3 | 2.0 | 0.003 |
| Ukiah | 2.4 | 36 | 0.5 | 80 | 14 | 0 | 1 | 3.3 | 4.0 | 1.8 | NA |

[a] Based on analysis of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis

1965. Average strontium–90 intake in the California diet varied from 2 to 46 pCi per capita per day. Cesium–137 intakes varied from 8 to 150 pCi per capita per day. Radium–226 intakes varied from 0.3 to 1.3 pCi per capita per day. The observed intakes of strontium–90, cesium–137, and radium–226 in California diets were of such a magnitude that no actions were indicated based upon health implications.

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(1) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, 1955, Report No. 1 (December 1956). Household Food Consumption Survey, Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

(2) U.S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary report, HASL–144:281–287 (April 1, 1964). Office of Technical Services, Department of Commerce, Washington, D.C. 20230. Summarized in Rad Health Data 5:285–288 (June 1964).

(3) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–147 (July 1, 1964). Office of Technical Services, Department of Commerce, Washington, D.C. 20230.

(4) BUREAU OF RADIOLOGICAL HEALTH, STATE OF CALIFORNIA, DEPARTMENT OF PUBLIC HEALTH. Rad Health News 4:4 (October 1965). 2151 Berkeley Way, Berkeley 4, California.

# Section II. Water

The Public Health Service (and as of January 1966, the Federal Water Pollution Control Administration) and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively, without considering other sources of radioactivity. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity.[1] Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. State programs recently covered in Radiological Health Data & Reports are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

| Program | Period reported | Last presented |
|---|---|---|
| Florida Water Sampling Program | 1964 | November 1965 |
| Kentucky Water Sampling Program | May 1963–June 1964 | March 1965 |
| Minnesota Surface Water Sampling Program | January–June 1965 | February 1966 |
| New York Surface Water Sampling Program | January–June 1965 | January 1966 |
| North Carolina Water Sampling Program | January–December 1964 | November 1965 |
| Washington Surface Water Sampling Program | July 1963–June 1964 | February 1965 |

REFERENCES


(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. Public Health Service Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

# GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, SEPTEMBER 1965

*Basic Data Branch Federal Water Pollution Control Administration*

The monitoring of levels of radioactivity in surface waters of the United States began in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the newly created Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 geographically presents the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytic procedures was published in the December 1965 *Radiological Health Data.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Comments on data are being made when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. Changes toward or from these levels are discussed in terms of significant changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will

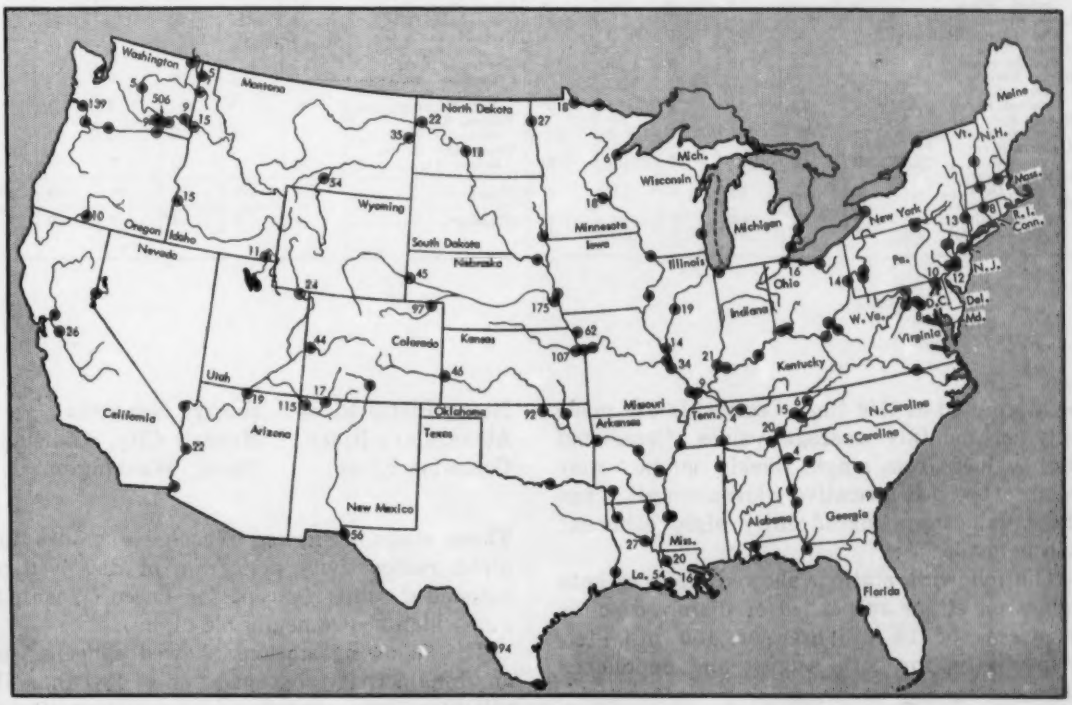


**Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, September 1965**

**Table 1. Radioactivity in raw surface waters, September 1965**
(average concentrations in pCi/liter)

| Station | Beta activity | | | Alpha activity | | |
|---|---|---|---|---|---|---|
| | Suspended | Dissolved | Total | Suspended | Dissolved | Total |
| Animas River: | | | | | | |
| Cedar Hill, N. Mex. | 11 | 6 | 17 | 3 | 1 | 4 |
| Arkansas River: | | | | | | |
| Coolidge, Kans. | 13 | 33 | 46 | 4 | 17 | 21 |
| Ponca City, Okla. | 73 | 19 | 92 | 23 | 4 | 27 |
| Atchafalaya River: | | | | | | |
| Morgan City, La. | 41 | 13 | 54 | 16 | 2 | 18 |
| Bear River: | | | | | | |
| Preston, Idaho | 0 | 11 | 11 | 0 | 1 | 1 |
| Big Horn River: | | | | | | |
| Hardin, Mont. | 33 | 21 | 54 | 11 | 7 | 18 |
| Chena River: | | | | | | |
| Fairbanks, Alaska | 12 | 3 | 15 | 4 | 1 | 5 |
| Clearwater River: | | | | | | |
| Lewiston, Idaho | 11 | 4 | 15 | 4 | 1 | 5 |
| Clinch River: | | | | | | |
| Clinton, Tenn. | 1 | 5 | 6 | 0 | 0 | 0 |
| Kingston, Tenn. | 3 | 12 | 15 | 0 | 0 | 0 |
| Colorado River: | | | | | | |
| Loma, Colo. | 22 | 22 | 44 | 6 | 5 | 11 |
| Page, Ariz. | 4 | 15 | 19 | 1 | 2 | 3 |
| Parker Dam, Calif.-Ariz. | 1 | 21 | 22 | 0 | 7 | 7 |
| Columbia River: | | | | | | |
| Wenatchee, Wash. | 0 | 5 | 5 | 0 | 0 | 0 |
| Pasco, Wash. | 63 | 443 | 506 | 0 | 1 | 1 |
| Clatskanie, Ore. | 13 | 126 | 139 | 0 | 1 | 1 |
| Connecticut River: | | | | | | |
| Enfield Dam, Conn. | 2 | 6 | 8 | 0 | 0 | 0 |
| Coosa River: | | | | | | |
| Rome, Ga. | 1 | 3 | 4 | 0 | 0 | 0 |
| Cumberland River: | | | | | | |
| Cheatham Lock, Tenn. | 0 | 4 | 4 | 0 | 0 | 0 |
| Delaware River: | | | | | | |
| Philadelphia, Pa. | 2 | 10 | 12 | 0 | 0 | 0 |
| Great Lakes: | | | | | | |
| Duluth, Minn. | 2 | 4 | 6 | 0 | 0 | 0 |
| Green River: | | | | | | |
| Dutch John, Utah | 1 | 23 | 24 | 0 | 4 | 4 |
| Hudson River: | | | | | | |
| Poughkeepsie, N.Y. | 2 | 11 | 13 | 0 | 0 | 0 |
| Illinois River: | | | | | | |
| Peoria, Ill. | 6 | 13 | 19 | 2 | 2 | 4 |
| Grafton, Ill. | 2 | 12 | 14 | 1 | 1 | 2 |
| Kansas River: | | | | | | |
| De Soto, Kans. | 78 | 29 | 107 | 21 | 5 | 26 |
| Klamath River: | | | | | | |
| Keno, Ore. | 2 | 8 | 10 | 0 | 0 | 0 |
| Maumee River: | | | | | | |
| Toledo, Ohio | 1 | 15 | 16 | 0 | 2 | 2 |
| Mississippi River: | | | | | | |
| St. Paul, Minn. | 2 | 16 | 18 | 0 | 1 | 1 |
| E. St. Louis, Ill. | 18 | 16 | 34 | 4 | 1 | 5 |
| New Roads, La. | 6 | 14 | 20 | 2 | 1 | 3 |
| New Orleans, La. | 2 | 14 | 16 | 1 | 2 | 3 |
| Missouri River: | | | | | | |
| Williston, N. Dak. | 5 | 17 | 22 | 1 | 4 | 5 |
| Bismarck, N. Dak. | 2 | 16 | 18 | <1 | 3 | 3 |
| St. Joseph, Mo. | 37 | 25 | 62 | 7 | 4 | 11 |
| North Platte River: | | | | | | |
| Henry, Nebr. | 3 | 42 | 45 | <1 | 28 | 28 |
| Ohio River: | | | | | | |
| Toronto, Ohio | 1 | 13 | 14 | 0 | 1 | 1 |
| Cairo, Ill. | 1 | 8 | 9 | 0 | 0 | 0 |
| Pend Oreille River: | | | | | | |
| Albeni Falls Dam, Idaho | <1 | 5 | 5 | 0 | 1 | 1 |
| Platte River: | | | | | | |
| Plattsmouth, Nebr. | 154 | 21 | 175 | 60 | 3 | 63 |
| Potomac River: | | | | | | |
| Washington, D.C. | 1 | 7 | 8 | 0 | 0 | 0 |
| Rainy River: | | | | | | |
| Baudette, Minn. | 2 | 16 | 18 | 0 | 0 | 0 |
| Red River, North: | | | | | | |
| Grand Forks, N. Dak. | 2 | 25 | 27 | 0 | 3 | 3 |
| Red River, South: | | | | | | |
| Alexandria, La. | 8 | 19 | 27 | 3 | 4 | 7 |
| Rio Grande: | | | | | | |
| El Paso, Tex. | 41 | 15 | 56 | 12 | 4 | 16 |
| Laredo, Tex. | 78 | 16 | 94 | 27 | 5 | 32 |
| San Joaquin River: | | | | | | |
| Vernalis, Calif. | 3 | 23 | 26 | 0 | 14 | 14 |
| San Juan River: | | | | | | |
| Shiprock, N. Mex. | 102 | 13 | 115 | 32 | 3 | 35 |
| Savannah River: | | | | | | |
| Port Wentworth, Ga. | 3 | 6 | 9 | <1 | 0 | <1 |
| Snake River: | | | | | | |
| Payette, Idaho | 2 | 13 | 15 | 0 | 5 | 5 |
| Wawawai, Wash. | 0 | 9 | 9 | 0 | 0 | 0 |
| South Platte River: | | | | | | |
| Julesburg, Colo. | 38 | 59 | 97 | 14 | 45 | 59 |
| Susquehanna River: | | | | | | |
| Conowingo, Md. | 1 | 9 | 10 | 0 | 0 | 0 |
| Tennessee River: | | | | | | |
| Chattanooga, Tenn. | 1 | 19 | 20 | 0 | 1 | 1 |
| Wabash River: | | | | | | |
| New Harmony, Ind. | 11 | 10 | 21 | 4 | 1 | 5 |
| Yakima River: | | | | | | |
| Richland, Wash. | 1 | 8 | 9 | 0 | 1 | 1 |
| Yellowstone River: | | | | | | |
| Sidney, Mont. | 18 | 17 | 35 | 7 | 5 | 12 |
| Maximum | 154 | 443 | 506 | 60 | 45 | 63 |
| Minimum | 0 | 3 | 4 | 0 | 0 | 0 |

be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

The following stations showed alpha or beta values on either suspended or dissolved solids in excess of 15 pCi/liter or 150 pCi/liter, respectively, for both August and September 1965:

South Platte River: Julesburg, Colorado
North Platte River: Henry, Nebraska
Atchafalaya River: Morgan City, Louisiana
Columbia River: Pasco, Washington

These stations showed reasonable values for alpha radioactivity per gram of dissolved or suspended solids (except for Pasco, Washington, which shows negligible alpha).

The following stations showed a decline to an alpha activity concentration of less than 15 pCi/liter or to somewhat higher values (Shiprock, New Mexico) than in the month of

August 1965:

| | |
|---|---|
| Arkansas River: | Coolidge, Kansas (alpha suspended) |
| San Juan River: | Shiprock, New Mexico |

The following stations showed increases of alpha radioactivity on dissolved or suspended solids from less than 15 pCi/liter in August to greater than this value for September 1965:

| | |
|---|---|
| Arkansas River: | Coolidge, Kansas (alpha suspended) |
| Arkansas River: | Ponca City, Oklahoma |
| Kansas River: | DeSoto, Kansas |
| Platte River: | Plattsmouth, Nebraska |
| Rio Grande: | Laredo, Texas |

At Morgan City, Louisiana, a single weekly sample high in suspended solids raised the average for the month on alpha radioactivity to a value just over 15 pCi/liter. Shiprock, New Mexico, declined in alpha radioactivity to its normal level, which usually exceeds 15 pCi/liter but only by small amounts. The beta radioactivity on dissolved solids at Pasco, Washington, approximately doubled over the previous month.

REFERENCES


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(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised) 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

# RADIOACTIVITY IN CALIFORNIA WATERS JANUARY–JUNE 1965[1]

*Bureau of Radiological Health, State of California*
*Department of Public Health*

Gross beta activity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out, and treated water sampling being substituted or continued. This procedural change is predicated upon sampling water at the point of consumption.

[1] Data from July and October 1965 issues of Radiological Health News, California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

**Figure 1. California surface water sampling stations**

**Table 1. Gross beta activity in California domestic waters (pCi/liter), January–June 1965**

| Sampling stations | Quality | January | February | March | April | May | June |
|---|---|---|---|---|---|---|---|
| Alturas | Well | *13 | NS | ND | *10 | *6 | ND |
| Antioch | Treated | *6 | ND | ND | *18 | ND | ND |
| Lake Arrowhead | Treated | NS | *4 | NS | *5 | *14 | *6 |
| Berkeley | Treated | *6 | *13 | *4 | *10 | NS | ND |
| Clearlake Highlands | Treated | *6 | ND | *10 | *9 | ND | ND |
| Crescent City | Raw | NS | NS | *1 | *6 | ND | ND |
| Death Valley | Treated | *12 | 2 | NS | ND | *6 | NS |
| Dos Palos | Treated | *22 | *12 | ND | *16 | *17 | *5 |
| El Centro | Treated | *20 | *9 | *3 | ND | ND | *16 |
| Eureka | Raw | *53 | *15 | ND | ND | ND | NS |
| | Treated | ND | *2 | ND | ND | ND | ND |
| Fort Bragg | Treated | *7 | *4 | ND | ND | NS | NS |
| Los Angeles Laboratory | Treated | *11 | ND | *3 | ND | ND | ND |
| Marin Municipal Water District | Treated | ND | *1 | *4 | *2 | ND | *9 |
| Mariposa | Treated | *11 | *6 | ND | *3 | ND | *2 |
| Metropolitan Water District of Southern California: | | | | | | | |
| Lake Havasu | Treated | ND | NS | NS | *3 | NS | *23 |
| Weymouth Plant | Treated | NS | *18 | *18 | *12 | 40 | *16 |
| Lake Millerton | Treated | *11 | *3 | *20 | NS | ND | *5 |
| Monterey | Treated | *7 | ND | ND | *14 | *12 | *4 |
| Naples | Treated | *5 | NS | NS | ND | *4 | *10 |
| Needles | Raw | ND | NS | NS | NS | NS | NS |
| North Marin Water District | Treated | *13 | ND | *5 | *17 | *4 | ND |
| | Raw | *14 | *2 | ND | *12 | 16 | *11 |
| | Sludge [b] | *91 | *54 | *15 | *99 | 54 | *10 |
| Oroville: | | | | | | | |
| California Water Service | Treated | *7 | *13 | ND | *4 | *3 | *7 |
| Wyandotte Irrigation District | Treated | *11 | *12 | *8 | *9 | NS | ND |
| Redding | Treated | *10 | *2 | ND | NS | NS | NS |
| Sacramento | Raw | ND | *3 | *1 | *9 | *3 | NS |
| Salinas | Well | NS | NS | NS | ND | *5 | NS |
| San Diego | Raw | NS | NS | *13 | ND | *28 | *2 |
| | Treated | ND | *19 | *14 | *23 | *8 | ND |
| San Francisco: | | | | | | | |
| Water Department | Treated | *11 | *2 | *7 | ND | *12 | ND |
| Alameda, East | Treated | *5 | *19 | *8 | *10 | ND | *3 |
| Brightside Weir | Raw | ND | ND | *19 | *2 | ND | *3 |
| Calaveras Reservoir | Raw | *8 | *2 | *9 | *1 | *4 | *4 |
| Crystal Springs | Treated | ND | *10 | *24 | *9 | *2 | *4 |
| Hetch Hetchy | Raw | NS | *15 | *13 | *10 | *5 | *4 |
| San Jose | Raw | *5 | *1 | *9 | ND | NS | NS |
| San Luis Obispo | Treated | *16 | NS | NS | *15 | NS | ND |
| Santa Barbara | Treated | ND | 37 | *5 | *7 | 19 | *2 |
| Santa Cruz | Coastal | ND | NS | NS | NS | *12 | NS |
| | Raw | *5 | *3 | NS | NS | NS | NS |
| | Treated | ND | NS | *5 | *10 | ND | *9 |
| Santa Rosa | Raw | ND | NS | NS | NS | NS | NS |
| | Treated | ND | ND | ND | ND | *2 | ND |
| Tahoe City | Raw | NS | 14 | ND | NS | NS | NS |
| | Treated | NS | NS | NS | *8 | NS | NS |
| Ukiah | Treated | NS | ND | NS | NS | ND | *9 |
| Vallejo: | | | | | | | |
| Fleming Hill | Raw | *20 | *15 | *5 | *14 | *12 | *3 |
| | Treated | *7 | ND | ND | *19 | *8 | *8 |
| Swanzy Reservoir | Treated | *7 | *4 | *17 | *6 | ND | ND |
| Willits | Treated | *9 | *7 | *3 | *16 | *11 | *2 |
| Yosemite | Treated | *18 | ND | *4 | *22 | ND | *16 |
| Maximum (not including sludge) | | 53 | 37 | 24 | 23 | 40 | 23 |
| Minimum | | 0 | 0 | 0 | 0 | 0 | 0 |

* When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.
[b] Sludge reported in pCi/g (dry weight).
NS, no sample collected.
ND, no detectable activity.

Most of the supplies sampled have as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or

surface streams. Under the present sampling schedule, monthly 500-ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a biannual basis.

*Analytical procedures*

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta activities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450° C. The ashed sample is dissolved and transferred to an aluminum planchet for beta counting. Gamma-emitting radionuclides are determined biannually on the composite samples.

*Discussion*

Table 1 shows the monthly average beta activity in the suspended-plus-dissolved solids in surface water supplies in California from January through June 1965. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has in general been undetectable or very slight, alpha activity analyses are not presented. No increase in the radioactivity level of surface water has been observed, while fallout levels continue to decline slowly.

REFERENCE

(*1*) DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59–6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

Previous coverage in *Radiological Health Data:*

| Period | Issue |
|---|---|
| 1961–June 1962 | *April 1963* |
| July–December 1962 | *September 1963* |
| January–June 1963 | *March 1964* |
| July–December 1963 | *September 1964* |
| January–June 1964 | *March 1965* |
| July–December 1964 | *September 1965* |

# Section III. Air and Deposition

## RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962.

Other air and deposition networks previously covered in *Radiological Health Data and Reports* follow:

| Network | Period reported | Last presented |
|---|---|---|
| National Air Sampling Network | July–September 1965 | January 1966 |
| HASL Fallout Network | April–December 1964 | September 1965 |

## 1. Radiation Surveillance Network November 1965

*Division of Radiological Health*
*Public Health Service*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during November 1965. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 291 air samples. Traces of longer-lived fresh fission products were identified on most of these.

**Figure 1. Radiation Surveillance Network sampling stations**

## Table 1. Gross beta activity in surface air and precipitation, October 1965

| Station location | | Air surveillance | | | | | | Precipitation | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number of samples | | Gross beta activity, pCi/m³ | | | Last profile in *RHD & R* | Total depth (mm) | Total deposition (nCi/m²)[a] |
| | | Air | Pptn | Maximum | Minimum | Average[a] | | | |
| Ala: | Montgomery | 30 | 3 | 0.16 | <0.10 | <0.10 | Feb 66 | 41 | <8 |
| Alaska: | Adak | 30 | | <0.10 | <0.10 | <0.10 | Sep 65 | (c) | |
| | Anchorage | 16 | 2 | 0.11 | <0.10 | <0.10 | Mar 66 | 7 | <1 |
| | Attu Island | 13 | | 0.13 | <0.10 | <0.10 | Oct 65 | (c) | |
| | Fairbanks | 8 | 4 | <0.10 | <0.10 | <0.10 | Jun 65 | 12 | <2 |
| | Juneau | 22 | 9 | <0.10 | <0.10 | <0.10 | Jul 65 | 88 | <18 |
| | Kodiak | 12 | | <0.10 | <0.10 | <0.10 | Aug 65 | (c) | |
| | Nome | 9 | | <0.10 | <0.10 | <0.10 | Dec 65 | (c) | |
| | Point Barrow | 28 | | <0.10 | <0.10 | <0.10 | Nov 65 | (c) | |
| | St. Paul Island | 29 | | <0.10 | <0.10 | <0.10 | Jan 66 | (c) | |
| Ariz: | Phoenix | 28 | | 0.23 | <0.10 | <0.12 | Jul 65 | (c) | |
| Ark: | Little Rock | 25 | 4 | 0.11 | <0.10 | <0.10 | Mar 66 | 44 | <9 |
| Calif: | Berkeley | 19 | 10 | 0.13 | <0.10 | <0.10 | Aug 65 | 139 | <28 |
| | Los Angeles | 20 | 8 | 0.18 | <0.10 | <0.11 | Dec 65 | 264 | <53 |
| C. Z: | Ancon | 11 | | <0.10 | <0.10 | <0.10 | Aug 65 | (c) | |
| Colo: | Denver | 28 | 1 | 0.15 | <0.10 | <0.11 | Aug 65 | 8 | <2 |
| Conn: | Hartford | 29 | 10 | <0.10 | <0.10 | <0.10 | Jul 65 | 50 | <10 |
| Del: | Dover | 20 | | <0.10 | <0.10 | <0.10 | Feb 66 | (c) | |
| D. C: | Washington | 28 | 5 | <0.10 | <0.10 | <0.10 | Nov 65 | 10 | <2 |
| Fla: | Jacksonville | 29 | 5 | 0.14 | <0.10 | <0.10 | Mar 66 | 56 | <11 |
| | Miami | 30 | 5 | 0.14 | <0.10 | <0.10 | Jul 65 | 67 | <13 |
| Ga: | Atlanta | (b) | | | | | Jan 66 | (c) | |
| Guam: | Agana | 29 | | <0.10 | <0.10 | <0.10 | Feb 66 | (c) | |
| Hawaii: | Honolulu | 30 | 6 | <0.10 | <0.10 | <0.10 | Oct 65 | 237 | <47 |
| Idaho: | Boise | 20 | 7 | <0.10 | <0.10 | <0.10 | Oct 65 | 30 | <6 |
| Ill: | Springfield | 30 | | 0.13 | <0.10 | <0.10 | Nov 65 | (c) | |
| Ind: | Indianapolis | 30 | 5 | 0.15 | <0.10 | <0.10 | Jan 66 | 32 | <7 |
| Iowa: | Iowa City | 28 | 2 | <0.10 | <0.10 | <0.10 | Aug 65 | 36 | <7 |
| Kans: | Topeka | 29 | 1 | <0.10 | <0.10 | <0.10 | Mar 66 | 3 | <1 |
| Ky: | Frankfort | 24 | 4 | 0.14 | <0.10 | <0.10 | Nov 65 | 19 | <4 |
| La: | New Orleans | 30 | 4 | 0.11 | <0.10 | <0.10 | Nov 65 | 44 | <9 |
| Maine: | Augusta | 30 | 14 | <0.10 | <0.10 | <0.10 | Dec 65 | 142 | <29 |
| | Presque Isle | 21 | 1 | <0.10 | <0.10 | <0.10 | Aug 65 | 17 | <3 |
| Md: | Baltimore | 20 | 2 | <0.10 | <0.10 | <0.10 | Jul 65 | 14 | <3 |
| | Rockville Lab | 12 | | 0.11 | <0.10 | <0.10 | Oct 65 | (c) | |
| Mass: | Lawrence | 30 | 9 | <0.10 | <0.10 | <0.10 | Feb 66 | 56 | <11 |
| | Winchester | 27 | 12 | <0.10 | <0.10 | <0.10 | Sep 65 | 69 | <14 |
| Mich: | Lansing | 30 | 8 | <0.10 | <0.10 | <0.10 | Oct 65 | 41 | <8 |
| Minn: | Minneapolis | 20 | 5 | <0.10 | <0.10 | <0.10 | Feb 66 | 58 | <12 |
| Miss: | Jackson | 28 | 2 | <0.10 | <0.10 | <0.10 | Dec 65 | 30 | <6 |
| Mo: | Jefferson City | 30 | 3 | <0.10 | <0.10 | <0.10 | Jan 66 | 18 | <4 |
| Mont: | Helena | 27 | 6 | <0.10 | <0.10 | <0.10 | Sep 65 | 16 | <3 |
| Nebr: | Lincoln | 18 | | 0.23 | <0.10 | <0.11 | Jan 66 | (c) | |
| Nev: | Las Vegas | 25 | 2 | 0.17 | <0.10 | <0.11 | Jun 65 | 22 | <4 |
| N. H: | Concord | 19 | | <0.10 | <0.10 | <0.10 | Nov 65 | (c) | |
| N. J: | Trenton | 30 | 3 | <0.10 | <0.10 | <0.10 | Dec 65 | 7 | <1 |
| N. Mex: | Santa Fe | 26 | 3 | 0.17 | <0.10 | <0.10 | Sep 65 | 14 | <3 |
| N. Y: | Albany | 15 | 8 | <0.10 | <0.10 | <0.10 | Jan 66 | 47 | <9 |
| | Buffalo | 28 | | <0.10 | <0.10 | <0.10 | Aug 65 | (c) | |
| | New York | 29 | | <0.10 | <0.10 | <0.10 | Sep 65 | (c) | |
| N. C: | Gastonia | 30 | 5 | 0.11 | <0.10 | <0.10 | Aug 65 | 67 | <13 |
| N. Dak: | Bismarck | 27 | 2 | 0.13 | <0.10 | <0.10 | Nov 65 | 4 | <1 |
| Ohio: | Cincinnati | 16 | | <0.10 | <0.10 | <0.10 | Feb 66 | (c) | |
| | Columbus | 29 | 7 | 0.16 | <0.10 | <0.10 | Dec 65 | 30 | <6 |
| | Painesville | 29 | 10 | 0.11 | <0.10 | <0.10 | Jul 65 | 96 | <19 |
| Okla: | Oklahoma City | 30 | | 0.12 | <0.10 | <0.10 | Oct 65 | (c) | |
| | Ponca City | 29 | | <0.10 | <0.10 | <0.10 | Jul 65 | (c) | |
| Ore: | Portland | 29 | 17 | 0.17 | <0.10 | <0.11 | Jan 66 | 93 | <19 |
| Pa: | Harrisburg | 28 | 4 | <0.10 | <0.10 | <0.10 | Jan 66 | 31 | <6 |
| P. R: | San Juan | 27 | 3 | 0.25 | <0.10 | <0.11 | Dec 65 | 59 | <12 |
| R. I: | Providence | 29 | 8 | <0.10 | <0.10 | <0.10 | Oct 65 | 56 | <11 |
| S. C: | Columbia | 29 | 5 | 0.11 | <0.10 | <0.10 | Sep 65 | 30 | <6 |
| S. Dak: | Pierre | 30 | | 0.15 | <0.10 | <0.10 | Jul 65 | (c) | |
| Tenn: | Nashville | 30 | 7 | <0.10 | <0.10 | <0.10 | Oct 65 | 51 | <10 |
| Tex: | Austin | 30 | 4 | 0.15 | <0.10 | <0.10 | Feb 66 | 86 | <17 |
| | El Paso | 28 | | 0.20 | <0.10 | <0.11 | Nov 65 | (c) | |
| Utah: | Salt Lake City | 30 | 10 | 0.15 | <0.10 | <0.11 | Dec 65 | 36 | <7 |
| Vt: | Barre | 28 | 15 | <0.10 | <0.10 | <0.10 | Mar 66 | 98 | <20 |
| Va: | Richmond | 29 | 3 | 0.11 | <0.10 | <0.10 | Mar 66 | 12 | <2 |
| Wash: | Seattle | 28 | 18 | <0.10 | <0.10 | <0.10 | Mar 66 | 99 | <20 |
| | Spokane | 30 | 5 | <0.10 | <0.10 | <0.10 | Feb 66 | 35 | <7 |
| W. Va: | Charleston | 27 | 3 | 0.12 | <0.10 | <0.10 | Sep 65 | 17 | <4 |
| Wis: | Madison | 30 | 6 | <0.10 | <0.10 | <0.10 | Mar 66 | 43 | <9 |
| Wyo: | Cheyenne | 29 | | 0.16 | <0.10 | <0.11 | Jun 65 | (c) | |
| Network summary | | 1,860 | 305 | 0.25 | <0.10 | <0.10 | | 52 | <11 |

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Indicates no report received.

[c] Indicates no precipitation sample collected.

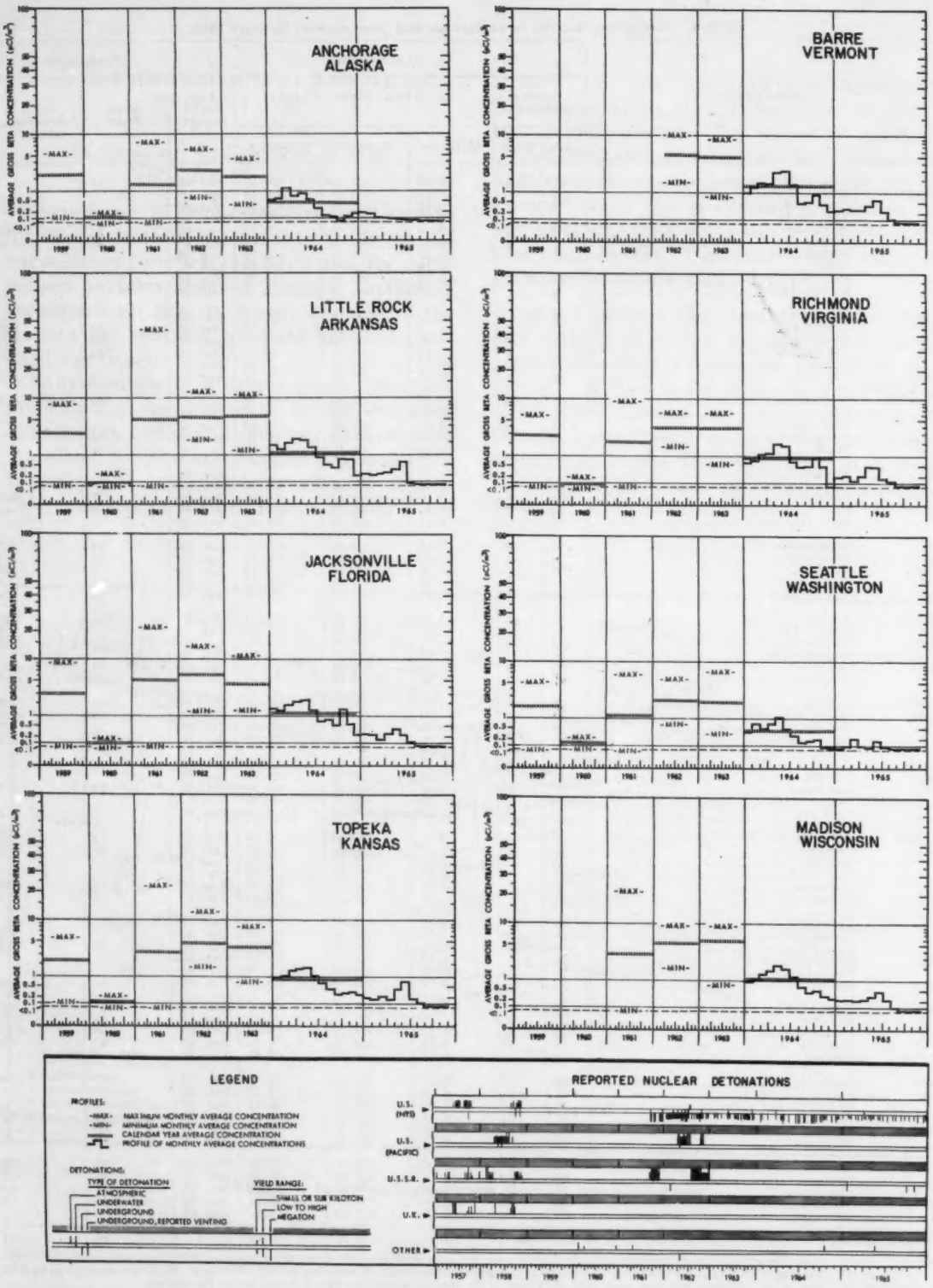


**Figure 2. Monthly and yearly profiles of beta activity in air, Radiation Surveillance Network, 1959–November 1965**

## 2. Canadian Air and Precipitation Monitoring Program, November 1965 [1]

*Radiation Protection Division*
*Department of National Health and Welfare*
*Ottawa, Canada*

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

[1] Prepared from information and data in the December 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for November 1965 are presented in table 2. Specific radionuclide data are presented in table 3.

**Table 2. Canadian gross beta activity in surface air and precipitation, November 1965**

| Station | Air Surveillance | | | | Precipitation measurements | |
|---|---|---|---|---|---|---|
| | Number of samples | Activity (pCi/m³) | | | Average concentration (pCi/liter) | Total deposition (nCi/m²) |
| | | Maximum | Minimum | Average | | |
| Calgary | 30 | 0.2 | 0.0 | 0.1 | 37 | 1.2 |
| Coral Harbour | 30 | 0.1 | 0.0 | 0.0 | 73 | 0.7 |
| Edmonton | 30 | 0.1 | 0.0 | 0.1 | 38 | 0.7 |
| Ft. Churchill | 29 | 0.1 | 0.0 | 0.0 | 31 | 0.8 |
| Ft. William | 30 | 0.1 | 0.0 | 0.0 | 21 | 1.7 |
| Fredericton | 30 | 0.1 | 0.0 | 0.0 | 16 | 2.2 |
| Goose Bay | 30 | 0.1 | 0.0 | 0.0 | 28 | 2.1 |
| Halifax | 29 | 0.1 | 0.0 | 0.1 | 27 | 3.0 |
| Inuvik | 30 | 0.1 | 0.0 | 0.1 | 42 | 0.5 |
| Montreal | 29 | 0.1 | 0.0 | 0.1 | 20 | 2.6 |
| Moosonee | 30 | 0.1 | 0.0 | 0.0 | 35 | 1.4 |
| Ottawa | 30 | 0.1 | 0.0 | 0.0 | 15 | 1.5 |
| Quebec | 29 | 0.1 | 0.0 | 0.0 | 20 | 2.7 |
| Regina | 30 | 0.1 | 0.0 | 0.1 | 38 | 0.9 |
| Resolute | 26 | 0.2 | 0.0 | 0.0 | 346 | 1.9 |
| St. John's, Nfld. | 29 | 0.1 | 0.0 | 0.0 | 22 | 3.8 |
| Saskatoon | 30 | 0.1 | 0.0 | 0.0 | 29 | 0.5 |
| Sault Ste. Marie | 26 | 0.1 | 0.0 | 0.1 | 19 | 2.9 |
| Toronto | 30 | 0.1 | 0.0 | 0.1 | 37 | 2.7 |
| Vancouver | 30 | 0.1 | 0.0 | 0.0 | 30 | 3.7 |
| Whitehorse | 30 | 0.1 | 0.0 | 0.1 | 50 | 1.0 |
| Windsor | 30 | 0.1 | 0.0 | 0.1 | 45 | 1.9 |
| Winnipeg | 29 | 0.1 | 0.0 | 0.1 | 34 | 1.5 |
| Yellowknife | 30 | 0.1 | 0.0 | 0.0 | 13 | 0.4 |
| Network summary | — | 0.2 | 0.0 | 0.0 | 44 | 1.8 |

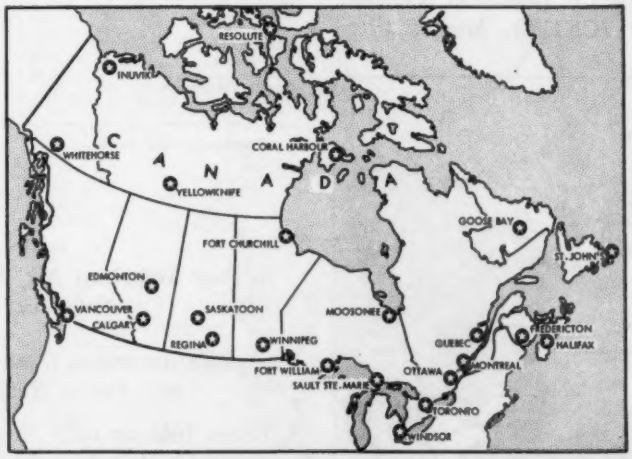


**Figure 3. Canadian air and precipitation sampling stations**

**Table 3. Radionuclide deposition, nCi/m², in Canadian fallout, November 1965[a]**

| Station | $^{90}Sr$ | $^{137}Cs$ |
|---|---|---|
| Calgary | 0.07 | 0.20 |
| Coral Harbour | 0.08 | 0.18 |
| Edmonton | 0.03 | 0.08 |
| Ft. Churchill | 0.03 | 0.06 |
| Ft. William | 0.05 | 0.15 |
| Fredericton | 0.11 | 0.21 |
| Goose Bay | 0.09 | 0.21 |
| Halifax | 0.22 | 0.43 |
| Inuvik | 0.01 | 0.08 |
| Montreal | 0.16 | 0.22 |
| Moosonee | 0.11 | 0.15 |
| Ottawa | 0.10 | 0.22 |
| Quebec | 0.15 | 0.47 |
| Regina | 0.03 | 0.06 |
| Resolute | 0.12 | 0.19 |
| St. John's, Nfld | 0.35 | 0.55 |
| Saskatoon | 0.04 | 0.06 |
| Sault Ste. Marie | 0.10 | 0.50 |
| Toronto | 0.22 | 0.30 |
| Vancouver | 0.30 | 0.49 |
| Whitehorse | 0.07 | 0.13 |
| Windsor | 0.11 | 0.20 |
| Winnipeg | 0.00 | 0.06 |
| Yellowknife | 0.02 | 0.04 |
| Average | 0.11 | 0.22 |

[a] Strontium-89, zirconium-95 and barium-140 are not reported due to insignificant levels.

## 3. Mexican Air Monitoring Program November 1965

*National Commission of Nuclear Energy*

The Radiation Surveillance Network of Mexico is operated by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City.

**Figure 4. Fallout network sampling stations in Mexico**

From 1952 to 1961, an earlier network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

The new Radiation Surveillance Network, operated by CNEN's Division of Radiological Protection, consists of 17 stations (see figure 4), 12 of which are located at airports and operated by airline personnel. The remaining five stations are operated by staff members of other agencies.

Sampling procedures were discussed in detail in the December 1965 issue of *Radiological Health Data.*

Table 4 presents the maximum, minimum, and average gross beta activity concentrations in surface air during November 1965.

**Table 4. Gross beta activity of airborne particulates, Mexico, November 1965**

| Station | Number of samples | Gross beta activity, pCi/m³ | | |
|---|---|---|---|---|
| | | Maximum | Minimum | Average |
| Acapulco[a] | | | | |
| Ciudad Juárez | 20 | 0.3 | <0.1 | 0.1 |
| Chihuahua | 19 | 0.2 | <0.1 | 0.1 |
| Enseñada | 12 | 0.2 | <0.1 | 0.1 |
| Guadalajara | 12 | 0.1 | <0.1 | <0.1 |
| Guaymas | 15 | 0.1 | <0.1 | <0.1 |
| La Paz | 4 | <0.1 | <0.1 | <0.1 |
| Matamoros | 1 | | | |
| Mazatlán | 2 | <0.1 | <0.1 | <0.1 |
| Mérida | 11 | 0.1 | <0.1 | <0.1 |
| México, D.F. | 13 | 0.1 | <0.1 | <0.1 |
| Nuevo Laredo | 9 | 0.2 | <0.1 | <0.1 |
| San Luis Potosí | 15 | 0.1 | <0.1 | <0.1 |
| Tampico | 20 | 0.2 | <0.1 | <0.1 |
| Torréon | 26 | 0.2 | <0.1 | <0.1 |
| Tuxtla Gutiérrez[a] | | | | |
| Veracruz | 6 | 0.1 | <0.1 | 0.1 |

[a] Temporarily shut down.

## 4. Pan American Air Sampling Program November 1965

*Pan American Health Organization and Public Health Service*

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO)

and the Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station profiles are shown in figure 5.

The November 1965 air monitoring results from the participating countries are given in table 5.

**Table 5. Gross beta activity in surface air, PAHO November 1965**

| Station locations | Number of samples | Gross beta activity, pCi/m³ | | |
|---|---|---|---|---|
| | | Maximum | Minimum | Average [a] |
| Argentina: Buenos Aires | 15 | 0.16 | <0.10 | <0.11 |
| Chili: Santiago | 30 | <0.10 | <0.10 | <0.10 |
| Jamaica: Kingston | 12 | <0.10 | <0.10 | <0.10 |
| Peru: Lima | [b] | | | |
| Venezuela: Caracas | 22 | <0.10 | <0.10 | <0.10 |
| West Indies: Trinidad | 21 | <0.10 | <0.10 | <0.10 |
| Pan American summary | 100 | 0.16 | <0.10 | <0.10 |

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.
[b] Indicates no report received

**Figure 5. Pan American Air Network sampling stations**

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(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program. CNHW–RP–3, Department of National Health and Welfare, Ottawa, Canada (May 1960).

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(*12*) BRODY, T. A., S. BULBULIAN, J. CALVILLO, and A. M. MARTINEZ. Quinto informe sobre estudios de precipitación radiactiva. Revista Mexicana de Física 10:1–30 (1961).

# Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

## RADIONUCLIDES IN ALASKAN CARIBOU AND REINDEER, 1963–1965

*Division of Radiological Health*
*Public Health Service*

Under a cooperative agreement between the Alaskan Departments of Health and Welfare and of Fish and Game, and the Public Health Service, an active program of caribou and reindeer sampling and analysis was undertaken in 1963 to aid in the assessment of radionuclide intake of Alaskan residents. The basis for this joint sampling activity was a limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou (*Rangifer caribou*) herds and one privately owned reindeer (*Rangifer tarandus*) herd. This program was expanded when, beginning in September 1964, the sampling of additional privately owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and Bureau of Indian Affairs, Department of Interior.

Figure 1 shows the locations and approximate number of animals in the caribou and reindeer herds sampled. In general, the reindeer herds are located on or near the Seward Peninsula and on two islands off the western coast of Alaska.

Samples of muscle, rumen contents, and bone from five animals (2- or 3-years old) in each herd sampled are collected in approximately April, July, September, and December of each year. The muscle samples, weighing about 2 pounds each, are frozen for shipment. The bone samples consist of the hock from each animal. The rumen content samples, weighing about 2 pounds wet, are frozen for shipment. All samples are shipped in dry ice to the Public Health Service Southwestern Radiological Laboratory in Las Vegas, Nevada, for analysis.

The analytical procedure includes gamma–

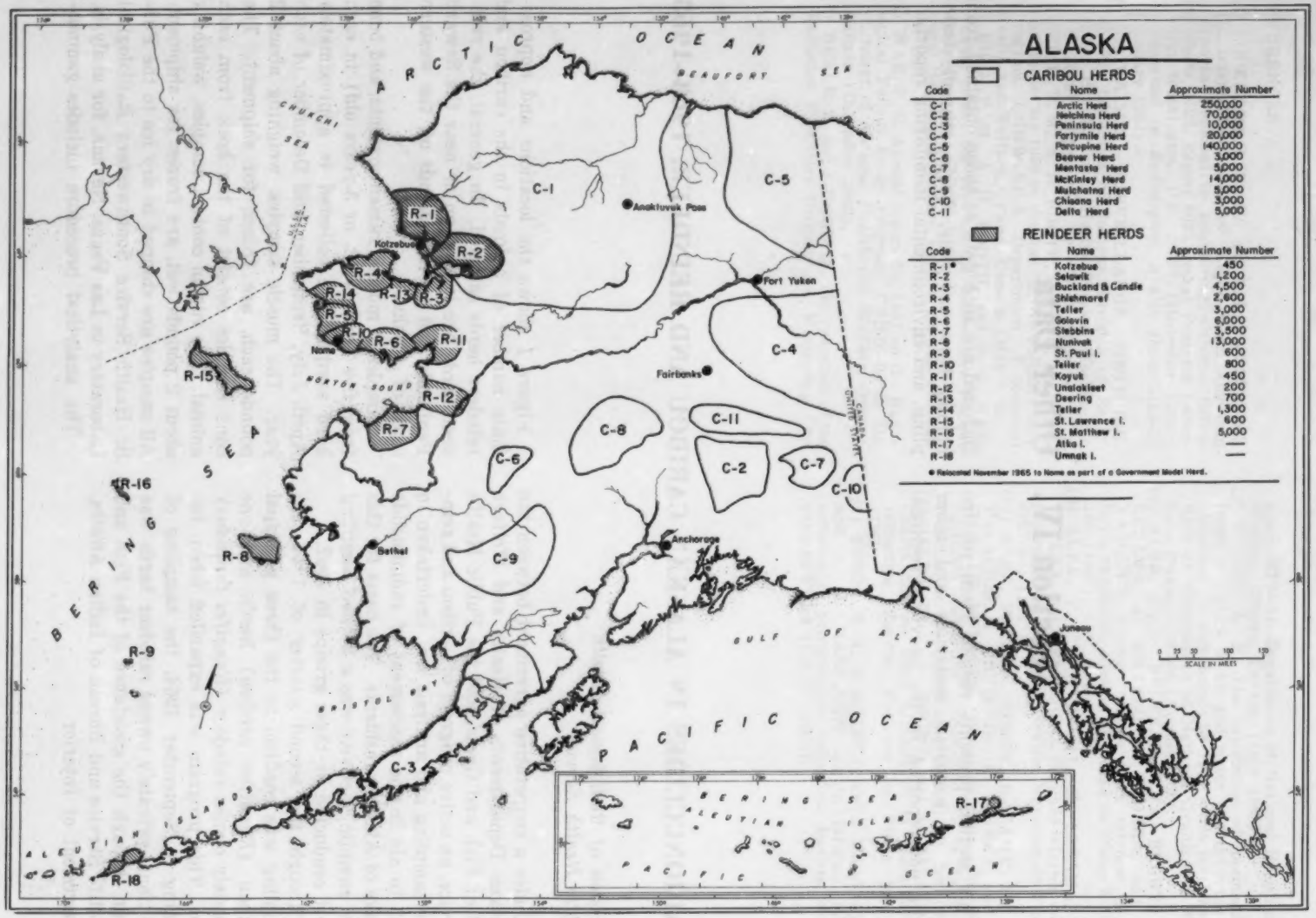


**Figure 1. Location and numbers of caribou and reindeer in herds sampled**

**Table 1. Average radionuclide values in caribou and reindeer muscle**

| Specimens and sampling dates | Number of samples | pCi/kg wet weight | | | |
|---|---|---|---|---|---|
| | | Strontium-89 | Strontium-90 | Cesium-137 | |
| | | | | Average | Range |
| Caribou | | | | | |
| Arctic herd | | | | | |
| 12/21/63 | 3 | [a] <5 | [a] 17 | 4,860 | 3,750- 5,680 |
| 4/27-5/19/64 | 5 | [a] <5 | [a] 400 | 13,800 | 5,000-21,000 |
| 8/20-8/29/64 | 5 | [a] <5 | [a] 40 | 700 | 400- 1,000 |
| 12/7-12/15/64 | 5 | [a] <5 | [a] 19 | 3,900 | 1,400- 5,300 |
| 4/14/65 | 5 | [a] <5 | [a] 22 | 9,600 | 6,300-14,000 |
| 9/20-10/2/65 | 5 | [a] <5 | [a] 11 | 7,720 | 4,000-12,000 |
| 11/16-11/22/65 | 5 | [a] 5 | [a] 1 | 6,220 | 4,300- 7,400 |
| Nelchina herd | | | | | |
| 11/24-11/25/63 | 5 | [a] 5 | [a] 33 | 21,800 | 16,900-26,400 |
| 4/24-4/26/64 | 5 | [a] 10 | [a] 54 | 5,560 | 2,600-10,000 |
| 8/26/64 | 1 | <5 | 31 | 14,300 | |
| 10/15/64 | 9 | [a] 5 | [a] 20 | 4,220 | 650- 6,200 |
| 12/8-12/9/64 | 5 | [a] <5 | [a] 30 | 14,000 | 7,900-22,000 |
| 3/27/65 | 5 | [a] <5 | [a] 48 | 27,600 | 16,000-39,000 |
| 7/27-7/28/65 | 5 | [a] <5 | [a] 7 | 4,000 | 1,600- 7,300 |
| 9/25-9/29/65 | 5 | <5 | [a] 26 | 8,160 | 5,900-10,000 |
| 12/4/65 | 5 | <5 | [a] 33 | 17,200 | 14,000-22,000 |
| Peninsula herd | | | | | |
| 12/12-12/19/63 | 5 | [a] 10 | [a] 84 | 44,800 | 33,600-57,700 |
| 4/9-4/15/64 | 5 | [a] <5 | [a] 14 | 14,800 | 13,000-18,000 |
| 7/11/64 | 4 | [a] <5 | [a] 5 | 1,680 | 1,400- 2,000 |
| 9/26-10/1/64 | 5 | [a] <5 | [a] 11 | 4,630 | 1,200- 9,250 |
| 12/14-12/17/64 | 5 | [a] <5 | 31 | 18,000 | 8,700-31,000 |
| 8/26/65 | 5 | [a] <5 | [a] 4 | 2,000 | 820- 3,200 |
| 9/29/65 | 5 | [a] <5 | [a] 15 | 18,000 | 11,000-32,000 |
| 11/10/65 | 5 | [a] <5 | [a] 7 | 20,100 | 12,400-25,000 |
| Reindeer | | | | | |
| R-1 | | | | | |
| 12/27/63 | 4 | [a] 5 | [a] 31 | 7,190 | 6,730- 7,540 |
| 9/7/64 | 5 | [a] 5 | [a] 74 | 3,340 | 2,300- 4,900 |
| 12/15/64 | 4 | [a] 5 | [a] 268 | 23,000 | 13,000-30,000 |
| R-2 | | | | | |
| 12/15/64 | 1 | 5 | 578 | 34,000 | |
| R-3 | | | | | |
| 9/26/64 | 2 | [a] 5 | [a] 68 | 19,600 | 13,400-25,800 |
| 12/15/64 | 4 | [a] 5 | [a] 64 | 14,000 | 5,100-32,000 |
| R-4 | | | | | |
| 9/25/64 | 3 | [a] 5 | [a] 38 | 8,490 | 7,660-10,000 |
| 12/15/64 | 5 | [a] 5 | [a] 68 | 12,000 | 4,900-29,000 |
| 3/6/65 | 5 | [a] 5 | [a] 25 | 18,000 | 13,000-24,000 |
| 9/2/65 | 5 | [a] <5 | [a] 14 | 6,000 | 4,000- 8,100 |
| 11/30/65 | 5 | [a] <5 | [a] 25 | 16,800 | 14,000-22,000 |
| R-5 | | | | | |
| 12/15/64 | 5 | [a] <5 | [a] 66 | 35,000 | 25,000-47,000 |
| 11/30/65 | 5 | [a] <5 | [a] 90 | 27,000 | 23,000-35,000 |
| R-6 | | | | | |
| 12/15/64 | 5 | [a] <5 | [a] 96 | 19,000 | 11,000-30,000 |
| R-7 | | | | | |
| 12/24/64 | 5 | [a] <5 | [a] 86 | 30,000 | 14,000-37,000 |
| R-8 | | | | | |
| 9/18/64 | 5 | [a] <5 | [a] 75 | 7,050 | 5,000- 9,200 |
| 12/24/64 | 5 | [a] <5 | [a] 128 | 25,000 | 9,800-35,000 |
| 4/1/65 | 5 | [a] <5 | [a] 28 | 31,200 | 27,000-34,000 |
| 8/18/65 | 35 | | | 7,700 | 4,000-15,000 |
| R-9 | | | | | |
| 9/24/64 | 4 | [a] <5 | [a] 10 | 4,800 | 2,080- 7,530 |
| 11/19-11/20/64 | 5 | [b] — | [b] — | 13,000 | 4,400-16,000 |
| R-13 | | | | | |
| 12/15/64 | 5 | [a] <5 | [a] 127 | 28,000 | 23,000-34,000 |

[a] Indicates samples composited before analysis.
[b] Dash indicates no analysis.

scintillation spectrometry for cesium–137 and other gamma emitters. Strontium–89 and strontium–90 are determined by chemical separation followed by beta counting. Analysis for stable calcium is done by a flame-photometric method.

Strontium–89, strontium–90, and cesium–137 data are presented in tables 1–3 for caribou and reindeer muscle, rumen contents, and bone, respectively, for the period November 1963 through December 1965.

The muscle data are of prime interest since muscle, in contrast to rumen or bone, is an important constituent of the diet for many

**Table 2. Average radionuclide values in Alaskan caribou and reindeer rumen contents**

| Specimens and sampling dates | Number of samples | pCi/kg wet weight | | | |
|---|---|---|---|---|---|
| | | Strontium-89 | Strontium-90 | Cesium-137 | |
| | | | | Average | Range |
| **Caribou** | | | | | |
| Arctic herd | | | | | |
| 12/21/63 | 3 | [a] 500 | [a] 4,440 | 4,430 | 3,980–4,770 |
| 4/27–5/19/64 | 5 | [a] <5 | [a] 1,680 | 4,440 | 4,000–6,000 |
| 8/20–8/29/64 | 5 | [a] 40 | [a] 1,700 | 1,470 | 970–2,200 |
| 10/2–10/23/64 | 5 | [a] <5 | [a] 4,500 | 5,080 | 4,400–6,100 |
| 12/7–12/15/64 | 5 | [a] <5 | [a] 4,020 | 4,100 | 1,800–6,300 |
| 4/14/65 | 5 | [b] — | [b] — | [a] 8,400 | |
| 9/20–10/2/65 | 5 | [b] — | [b] — | [a] 4,700 | |
| 11/16/65 | 5 | [b] — | [b] — | [a] 5,600 | |
| Nelchina herd | | | | | |
| 11/24–11/25/63 | 5 | [a] 400 | [a] 5,150 | 4,880 | 1,100–7,430 |
| 4/24–4/26/64 | 5 | [a] <5 | [a] 1,550 | 8,400 | 2,500–12,000 |
| 8/26/64 | 1 | <5 | 346 | 8,900 | |
| 10/15/64 | 9 | [a] <5 | [a] 207 | 3,030 | 550–4,500 |
| 12/8–12/9/64 | 5 | [a] <5 | [a] 4,430 | 7,200 | 4,300–9,000 |
| 3/27/65 | 5 | [b] — | [b] — | [a] 8,600 | |
| 7/27–7/28/65 | 5 | [b] — | [b] — | [a] 5,100 | |
| 9/25–9/29/65 | 5 | [b] — | [b] — | [a] 7,600 | |
| 12/4/65 | 5 | [b] — | [b] — | [a] 6,500 | |
| Peninsula herd | | | | | |
| 12/12–12/19/63 | 5 | [a] 1,550 | [a] 5,700 | 7,920 | 4,020–12,300 |
| 4/9–4/15/64 | 5 | [a] <5 | [a] 1,300 | 1,840 | 1,400–2,600 |
| 7/11/64 | 5 | [a] <5 | [a] 311 | 690 | 620–740 |
| 9/26–10/1/64 | 5 | [a] <5 | [a] 825 | 5,890 | 1,500–13,300 |
| 12/14–12/17/64 | 5 | [a] 3,120 | [a] 2,410 | 4,900 | 2,200–8,000 |
| 8/26/65 | 5 | [a] <5 | [a] 487 | [a] 770 | |
| 9/26/65 | 5 | [b] — | [b] — | [a] 6,600 | |
| 11/10/65 | 5 | [b] — | [b] — | [a] 8,100 | |
| **Reindeer** | | | | | |
| R–1 | | | | | |
| 12/27/63 | 4 | [a] <5 | [a] 5,600 | 4,650 | 3,760–5,360 |
| 12/15/64 | 5 | [a] <5 | [a] 4,480 | 5,400 | 2,300–7,900 |
| R–2 | | | | | |
| 12/15/64 | 1 | <5 | 3,910 | 6,900 | |
| R–3 | | | | | |
| 9/26/64 | 1 | <5 | 315 | 10,900 | |
| 12/15/64 | 3 | [a] <5 | [a] 5,810 | 5,500 | 5,200–5,700 |
| R–4 | | | | | |
| 9/25/64 | 1 | <5 | 1,710 | 5,770 | |
| 12/15/64 | 5 | [a] <5 | [a] 2,440 | 1,900 | 1,000–2,700 |
| 11/30/65 | 5 | [b] — | [b] — | [a] 5,000 | |
| R–5 | | | | | |
| 11/30/65 | 5 | [b] — | [b] — | [a] 5,600 | |
| R–8 | | | | | |
| 9/18/64 | 5 | [a] 5 | [a] 3,060 | 3,600 | 2,500–4,510 |
| 12/24/64 | 5 | [a] <5 | [a] 4,040 | 5,400 | 1,100–10,000 |
| R–9 | | | | | |
| 9/24/64 | 4 | [a] <5 | [a] 720 | 1,070 | 660–1,900 |
| 11/19–11/20/64 | 5 | [b] — | [b] — | 4,400 | 1,700–8,500 |
| R–11 | | | | | |
| 12/15/64 | 5 | [a] <5 | [a] 4,930 | 4,600 | 2,400–7,400 |

[a] Indicates samples composited before analysis.
[b] Dash indicates no analysis.

Alaskan residents. A tendency toward increased cesium–137 values in caribou and reindeer muscle during and immediately following the winter diet and lower values during and immediately following the summer diet can be seen. Also, a trend is noted in caribou muscle values with the Peninsula herd reaching the highest concentrations in the winter months and the Nelchina herd following. However, the concentration of cesium–137 decreases sooner in these animals than the Arctic herd because of an earlier spring where they graze.

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| 1962–1964 | *December 1964* |
| 1963–1964 | *May 1965* |

**Table 3. Average radionuclide values in Alaskan caribou and reindeer bone**

| Specimens and sampling dates | Number of samples | pCi/g ash | | pCi/kg wet weight | |
|---|---|---|---|---|---|
| | | Strontium-89 | Strontium-90 | Cesium-137 | |
| | | | | Average | Range |
| **Caribou** | | | | | |
| Arctic herd | | | | | |
| 12/21/63 | 3 | [a] 60 | [a] 225 | 170 | 120–210 |
| 4/27–5/19/64 | 5 | [a] <5 | [a] 143 | [b] — | |
| 8/20–8/29/64 | 5 | [a] <5 | [a] 137 | [b] — | |
| 10/2–10/23/64 | 5 | [a] <5 | [a] 128 | 714 | 510–920 |
| 12/7–12/15/64 | 5 | [a] <5 | [a] 125 | [b] — | |
| 4/11–4/14/65 | 5 | | | | |
| 11/16–11/22/65 | 5 | | | | |
| Nelchina herd | | | | | |
| 11/24–11/25/63 | 5 | [a] <5 | [a] 117 | 920 | 520–1,940 |
| 4/24–4/26/64 | 5 | [a] <5 | [a] 143 | [b] — | |
| 10/15/64 | 9 | [a] <5 | [a] 84 | 790 | 470–1,000 |
| 12/8/64 | 5 | [a] <5 | [a] 69 | [b] — | |
| 12/4/65 | 5 | | | | |
| Peninsula herd | | | | | |
| 12/12–12/19/63 | 5 | [a] <5 | [a] 118 | 3,920 | 3,240–4,780 |
| 4/9–4/15/64 | 5 | [a] <5 | [a] 116 | [b] — | [c] ND–2,180 |
| 9/26–10/1/64 | 5 | [a] <5 | [b] 114 | 810 | |
| 7/11/64 | 4 | [a] <5 | [a] 115 | [b] — | |
| 12/14–12/17/64 | 5 | [a] <5 | [a] 169 | [b] — | |
| 8/26/65 | 5 | [a] <5 | [a] 776 | [b] — | |
| 11/10/65 | 4 | | | | |
| **Reindeer** | | | | | |
| R-1 | | | | | |
| 12/27/63 | 4 | [a] 25 | [a] 64 | 830 | 750–920 |
| 9/7/64 | 5 | [a] <5 | [a] 96 | 2,240 | 1,300–2,700 |
| 12/15/64 | 5 | [a] <5 | [a] 116 | [b] — | |
| R-2 | | | | | |
| 12/15/64 | 1 | <5 | 105 | [b] — | |
| R-3 | | | | | |
| 9/26/64 | 2 | [a] <5 | [a] 184 | 3,670 | 1,880–5,460 |
| 12/15/64 | 5 | [a] 7 | [a] 175 | [b] — | |
| R-4 | | | | | |
| 9/25/64 | 3 | [a] <5 | [a] 115 | 2,050 | 1,080–2,880 |
| 12/15/64 | 5 | [a] <5 | [a] 135 | [b] — | |
| R-5 | | | | | |
| 12/15/64 | 4 | [a] <5 | [a] 185 | [b] — | |
| R-6 | | | | | |
| 12/15/64 | 5 | [a] <5 | [a] 197 | [b] — | |
| R-7 | | | | | |
| 12/24/64 | 5 | [a] <5 | [a] 269 | [b] — | |
| R-8 | | | | | |
| 9/18/64 | 5 | [a] <5 | [a] 185 | 1,420 | 1,080–1,790 |
| 12/24/64 | 5 | [a] <5 | [a] 178 | 2,000 | 360–3,700 |
| R-9 | | | | | |
| 9/24/64 | 4 | [a] <5 | [a] 64 | 460 | 340–610 |
| 11/19–11/20/64 | 5 | [a] <5 | [a] 214 | 750 | 400–880 |
| R-11 | | | | | |
| 12/15/64 | 5 | [a] <5 | [a] 214 | [b] — | |
| R-13 | | | | | |
| 12/15/64 | 5 | [a] <5 | [a] 177 | [b] — | |

[a] Indicates samples composited before analysis.
[b] Dash indicates no analysis.
[c] ND indicates not detectable.

# ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Argonne National Laboratory, Atomics International, Feed Materials Production Facilities, and National Reactor Testing Station.

## 1. Argonne National Laboratory January–June 1965[2]

*University of Chicago*
*Lemont, Illinois*

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, January–June 1965," University of Chicago, Lemont, Illinois.

*Air monitoring*

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. Sampling on charcoal for radioactive iodine was conducted on the site only. Iodine activity in excess of the minimum detectable concentration of 0.2 pCi/m³ (0.2 percent of the MPC[1]) was not detected. The total alpha and beta activities in the air-filter samples are summarized in table 1. No activity attributable to Argonne operations was found in any of these samples. The alpha activities were normal both on and off the site and were in the range found in previous years. The beta activity was due prin-

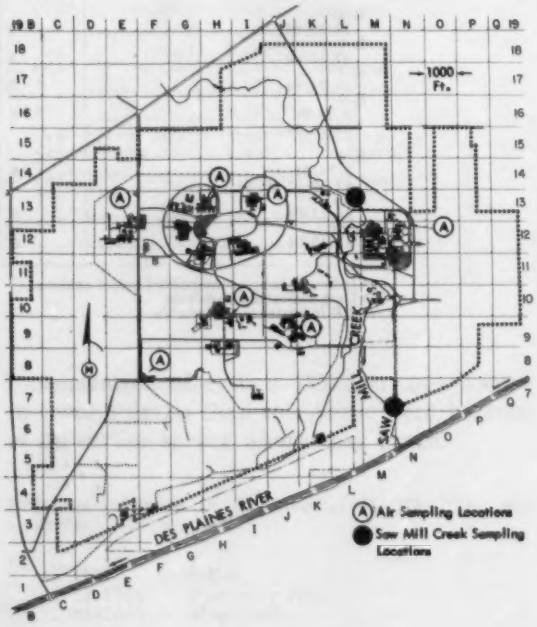


**Figure 1. Sampling locations on the site of Argonne National Laboratory**

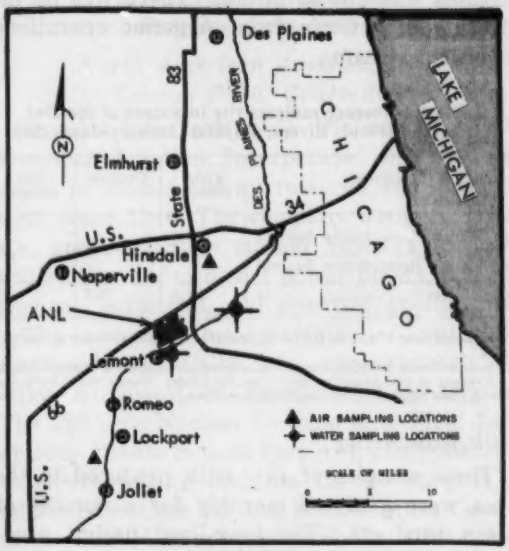


**Figure 2. Sampling locations near Argonne National Laboratory**

cipally to long-lived fission and neutron activation products from nuclear test detonations of previous years. In addition, short-lived fission products from a nuclear detonation conducted on the Chinese mainland on May 14, 1965, were present in air beginning on May 21. The increase in radioactivity due to this test was about 0.2 pCi/m³, about the same as that observed after the first Chinese test in October 1964. Concentrations of several fission products in air are given in table 2.

### *Water monitoring*

Argonne waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the waste water on the radio-

**Table 1. Total alpha and beta activities in air-filter samples, January–June 1965 [a]**

| Month, 1965 | Location | Number of samples | Alpha activity, pCi/m³ | | | Beta activity, pCi/m³ | | |
|---|---|---|---|---|---|---|---|---|
| | | | Average | Minimum | Maximum | Average | Minimum | Maximum |
| January | Onsite | 27 | 0.0039 | 0.0019 | 0.0070 | 0.2 | 0.1 | 0.3 |
| | Offsite | 23 | 0.0039 | 0.0019 | 0.0063 | 0.2 | 0.1 | 0.3 |
| February | Onsite | 21 | 0.0037 | 0.0004 | 0.0067 | 0.3 | 0.1 | 0.4 |
| | Offsite | 18 | 0.0038 | 0.0022 | 0.0061 | 0.3 | 0.2 | 0.4 |
| March | Onsite | 27 | 0.0033 | 0.0018 | 0.0079 | 0.3 | 0.2 | 0.5 |
| | Offsite | 18 | 0.0030 | 0.0013 | 0.0056 | 0.3 | 0.2 | 0.5 |
| April | Onsite | 25 | 0.0040 | 0.0017 | 0.0075 | 0.3 | 0.2 | 0.4 |
| | Offsite | 16 | 0.0045 | 0.0021 | 0.0075 | 0.3 | 0.2 | 0.5 |
| May | Onsite | 24 | 0.0037 | 0.0024 | 0.0070 | 0.4 | 0.2 | 0.7 |
| | Offsite | 17 | 0.0040 | 0.0023 | 0.0059 | 0.4 | 0.3 | 0.5 |
| June | Onsite | 25 | 0.0034 | 0.0021 | 0.0060 | 0.6 | 0.4 | 1.1 |
| | Offsite | 23 | 0.0038 | 0.0014 | 0.0057 | 0.7 | 0.4 | 1.2 |
| Summary | Onsite | 149 | 0.0037 | 0.0004 | 0.0079 | 0.4 | 0.1 | 1.1 |
| | Offsite | 115 | 0.0038 | 0.0013 | 0.0075 | 0.4 | 0.1 | 1.2 |

[a] These results were obtained by measuring the samples four days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products. This activity is normally present in the air and disappears within four days by radioactive decay.

**Table 2. Gamma-ray activity in air-filter samples, January–June 1965, pCi/m³**

| Radionuclides | Location | January | February | March | April | May | June | Average |
|---|---|---|---|---|---|---|---|---|
| Antimony-125 | Onsite | <0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | Offsite | <0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Barium-140–lanthanum-140 | Onsite | <0.01 | <0.01 | <0.01 | <0.01 | 0.05 | 0.09 | 0.03 |
| | Offsite | <0.01 | <0.01 | <0.01 | <0.01 | 0.06 | 0.11 | 0.03 |
| Cerium-144 | Onsite | 0.06 | 0.09 | 0.11 | 0.11 | 0.11 | 0.15 | 0.11 |
| | Offsite | 0.07 | 0.11 | 0.13 | 0.11 | 0.13 | 0.13 | 0.12 |
| Cesium-137 | Onsite | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 |
| | Offsite | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 |
| Ruthenium-106–rhodium-106 | Onsite | 0.05 | 0.04 | 0.06 | 0.05 | 0.09 | 0.07 | 0.06 |
| | Offsite | 0.05 | 0.04 | 0.06 | 0.08 | 0.06 | 0.09 | 0.06 |
| Zirconium-95–niobium-95 | Onsite | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | 0.04 | 0.01 |
| | Offsite | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | 0.05 | 0.01 |

activity in the creek. Radioactivity from Argonne waste water, in amounts well below the MPC's, was found in some samples of Sawmill Creek water collected below the discharge. The concentrations of radioactive materials at this location are summarized in table 3. The table gives the average and maximum concentrations in pCi/liter as well as the corresponding percentages of the MPC's.

A comparison of these concentrations with those above the discharge indicates that most of the uranium, thorium, plutonium, cesium–137, and cobalt–60 was added to the creek in the waste water while most of the strontium–90 was due to fallout.

**Table 3. Radioactivity in Sawmill Creek water below waste water discharge, January–June 1965**

| Element or nuclide | Concentration (pCi/liter) | | Percent of MPC | |
|---|---|---|---|---|
| | Average | Maximum | Average | Maximum |
| Barium-140 | — | <2 | — | <0.007 |
| Cesium-137 | 1.1 | 3.3 | 0.006 | 0.017 |
| Cobalt-58 | — | <5 | — | <0.005 |
| Cobalt-60 | 1.6 | 14.1 | 0.003 | 0.028 |
| Iodine-131 | — | <3 | — | <1 |
| Plutonium | <0.05 | 0.34 | <0.001 | 0.007 |
| Strontium-89 | — | <2 | — | <0.02 |
| Strontium-90 | 2.7 | 5.5 | 0.9 | 1.8 |
| Thorium-232 | 0.11 | 0.81 | 0.005 | 0.041 |
| Thorium-234–protactinium-234 | 1.9 | 7.7 | 0.010 | 0.039 |
| Tritium | — | <4,000 | — | <0.13 |
| Uranium | 2.7 | 10.6 | 0.007 | 0.027 |

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in these two streams is important in determining the effect of Argonne operations on the environmental radioactivity. The alpha, beta, and uranium activities found in these streams are summarized in table 4. Des Plaines River water was also analyzed for the other nuclides found in Sawmill Creek and, as was the case for the results in table 4, no significant differences in radioactivity between sampling locations of the river could be found. Apparently as a result of dilution, the activity in Sawmill Creek had no detectable effect on the radioactivity in the Des Plaines River. The alpha activities in the Des Plaines and Illinois Rivers were in the normal range and similar to earlier values. The natural beta activity in the Des Plaines and Illinois Rivers varies between 5 and 10 pCi/liter. The additional beta activity in these streams was due to fallout. There was no indication of activity from Argonne operations in either stream.

**Table 4. Average radioactivity in waters of the Des Plaines and Illinois Rivers, pCi/liter, January–June 1965**

| Locations | Alpha activity | Uranium | Beta activity |
|---|---|---|---|
| Des Plaines River (above Sawmill Creek)[a] | 2.4 | 1.8 | 20 |
| Des Plaines River (below Sawmill Creek)[b] | 2.3 | 1.5 | 20 |
| Illinois River[c] | 2.4 | 2.2 | 16 |

[a] Sampled near Highway Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[c] Average of two sampling locations: McKinley Woods State Park and Morris. See figure 2 for all sampling locations.

### *Milk monitoring*

Three samples of raw milk produced in the area were analyzed monthly for a number of fisson products. The long-lived fission products, cesium–137, and strontium–90 were present in all samples. Their average concentrations were 80 and 14 pCi/liter, respectively. The shorter-lived fission products, barium–140 and strontium–89 were found only in the samples collected June 4, 1965, and are attributed to the Chinese test of May 14. The concentrations of these fission products in the June samples were 24 and 14 pCi/liter, respectively.

### *Summary*

Fallout activity was present in all types of samples and at all locations throughout the year, but in lower concentration than in 1964. Argonne's contribution to the environment was confined to Sawmill Creek below the wastewater discharge. Radioactivity originating at Argonne was not found in any other material or at any other location off the site. The concentrations of radioactive substances added to the environment during the year by Argonne were considerably less than the MPC's and did not constitute a health hazard.

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| July–December 1960 | *July 1961* |
| January–June 1961 | *December 1961* |
| July–December 1961 | *May 1962* |
| Calendar year 1962 | *May 1963* |
| Calendar year 1963 | *August 1964* |
| January–June 1964 | *March 1965* |
| July-December 1964 | *September 1965* |

## 2. Atomics International January–June 1965 [3]

*North American Aviation, Inc.*
*Canoga Park, California*

Atomics International, a Division of North American Aviation, Incorporated, has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants, and for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, California, approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 3.

[3] Summarized from "Environmental Monitoring, Semiannual Report, January 1, 1965, to June 30, 1965," Atomics International.

The basic concept of radiological hazard control at Atomics International encourages total containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check on the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design.

The environs of Atomics International headquarters and Nuclear Development Field Laboratory (NDFL), are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. In addition, continuous environmental air monitoring at the sites provides information concerning airborne particulate radioactivity.

### *Air monitoring*

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a filter tape which is automatically changed at the end of each

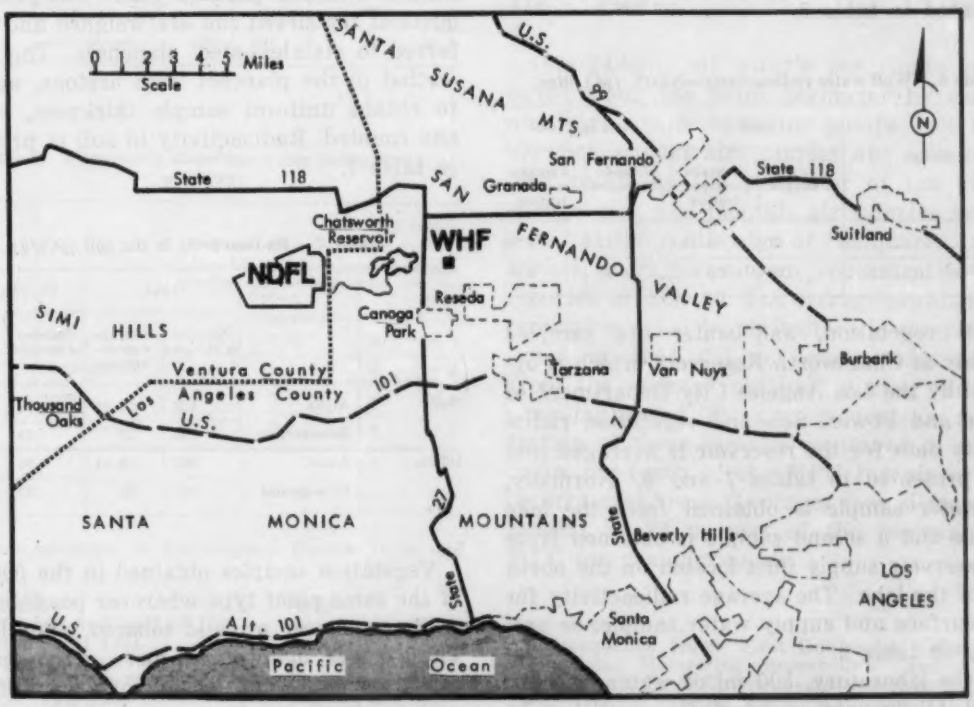


**Figure 3. Atomics International Facilities and vicinity**

sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 21 cubic meters. The average concentration of airborne particulates is presented in table 5.

**Table 5. Radioactivity of airborne particulates (beta-gamma activity, pCi/m³)**

| Location | 1964 | | First half 1965 | |
|---|---|---|---|---|
| | Number of samples | Average concentration | Number of samples | Average concentration |
| Headquarters | 355 | 2.7 | 182 | 2.0 |
| NDFL | Insufficient data | | 69 | 1.9 |

*Water monitoring*

Process water used at the NDFL is obtained from wells and stored in 50,000-gallon tanks. Potable water is delivered to the site by a vendor and is not analyzed. Well water is sampled monthly from the supply line at two locations. The average well water radioactivity is presented in table 6.

**Table 6. Well water radioactivity—NDFL (pCi/liter)**

| Activity | 1964 | | First half 1965 | |
|---|---|---|---|---|
| | Number of samples | Average concentration | Number of samples | Average concentration |
| Alpha | 23 | <0.18 | 12 | 0.22 |
| Beta-gamma | 23 | <5.3 | 12 | 6.5 |

Soil, vegetation, and water are sampled monthly at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power. Soil and vegetation radioactivity data for the reservoir is averaged into data presented in tables 7 and 8. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir supply inlet located on the north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 9.

In the laboratory, 500 ml of water is evaporated to dryness in crystallizing dishes at approximately 90°C. The residue salts are transferred to stainless-steel planchets, wetted with distilled water to produce a uniform sample distribution, redried under infrared lamps, and counted.

*Soil and vegetation monitoring*

Soil and vegetation are sampled monthly at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis.

Sample preparation consists of transferring the soils to Pyrex beakers and drying in a muffle furnace at 500°C. for approximately 8 hours. After cooling, the soil is sieved to obtain a uniform particle size. One-gram aliquots of the sieved soil are weighed and transferred to stainless-steel planchets. The soil is wetted in the planchet with acetone, agitated to obtain uniform sample thickness, redried and counted. Radioactivity in soil is presented in table 7.

**Table 7. Radioactivity in the soil (pCi/g)**

| Area | Activity | 1964 | | First half 1965 | |
|---|---|---|---|---|---|
| | | Number of samples | Average concentration | Number of samples | Average concentration |
| Onsite | Alpha | 152 | <0.46 | 72 | 0.49 |
| | Beta-gamma | 146 | 32 | 72 | 24 |
| Offsite | Alpha | 299 | <0.44 | 70 | <0.51 |
| | Beta-gamma | 293 | 26 | 70 | 17 |

Vegetation samples obtained in the field are of the same plant type wherever possible, generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area.

Vegetation leaves are stripped from plants and placed in ice cream cartons for transfer to the laboratory for analysis. Plant root systems are not routinely sampled.

Vegetation samples are first washed with tap water to remove foreign matter and then thoroughly rinsed in distilled water. Washed vegetation is placed in porcelain crucibles and ashed in a muffle furnace at 500°C. for approximately 8 hours, producing a completely oxidized ash. Three hundred milligram aliquots of pulverized ash from each crucible are weighted and transferred to stainless-steel planchets for counting. Radioactivity in vegetation is presented in table 8.

**Table 8. Radioactivity in vegetation (pCi/g ash)**

| Area | Activity | 1964 | | First half 1965 | |
|---|---|---|---|---|---|
| | | Number of samples | Average concentration | Number of samples | Average concentration |
| Onsite | Alpha | 154 | <0.50 | 72 | <0.62 |
| | Beta-gamma | 148 | 211 | 72 | 177 |
| Offsite | Alpha | 293 | <0.51 | 70 | 0.78 |
| | Beta-gamma | 299 | 181 | 70 | 156 |

**Table 9. Chatsworth Reservoir water radioactivity (pCi/liter)**

| Sample | Activity | 1964 | | First half 1965 | |
|---|---|---|---|---|---|
| | | Number of samples | Average concentration | Number of samples | Average concentration |
| Lake surface | Alpha | 18 | 0.71 | 6 | 0.53 |
| | Beta-gamma | 18 | 10 | 6 | 9.8 |
| Supply inlet | Alpha | 12 | 0.49 | 6 | 0.44 |
| | Beta-gamma | 12 | 8.8 | 6 | 12.2 |

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| 1960 and first half of 1961 | *December 1961* |
| Second half 1961 | *August 1962* |
| Calendar year 1962 | *November 1963* |
| Calendar year 1963 | *September 1964* |
| First half 1964 | *March 1965* |
| Second half 1964 | *September 1965* |

## 3. Feed Materials Production Facilities January–December 1964 [4]

*Mallinckrodt Chemical Works*
*Weldon Spring, Missouri*

Environmental monitoring results at the Feed Materials Production Facilities (FMPF) are reported in uranium concentrations since uranium ore concentrates constitute the primary feed material.

Process chemical wastes and other process residues are permanently retained in storage facilities (figure 4) located at the plant site and at two storage sites (one adjacent to the Lambert-St. Louis Municipal Airport and the other at a quarry near the Missouri River). The plant process sewer, which carries the remaining water effluent from the operations into the Missouri River, is automatically sampled daily to permit continual measurement of any release of uranium-bearing material into the river.

### *Air monitoring*

One 24-hour air sample per month is collected along the plant perimeter by each of nine high-volume sampling pumps (see figure 5). Semiannual air samples are collected at four points on the perimeter of the airport storage site, and monthly air samples are collected at the south edge of the quarry. Semiannual average uranium concentrations are reported in table 10. The average uranium concentration noted in perimeter air samples collected in 1964 did not change significantly from the average obtained during the 1963 sampling period. The average uranium concentration of these samples continued to remain below one-tenth of the MPC for air or nonoccupational areas. Averages ranged from 0.15 percent to 24 percent of the environmental MPC for uranium in air.

[4] Summarized from "First Semiannual Off-site Environmental Monitoring Report–1964" and "Second Semiannual Off-site Environmental Monitoring Report–1964," Weldon Spring Plant, Mallinckrodt Chemical Works, Uranium Division.

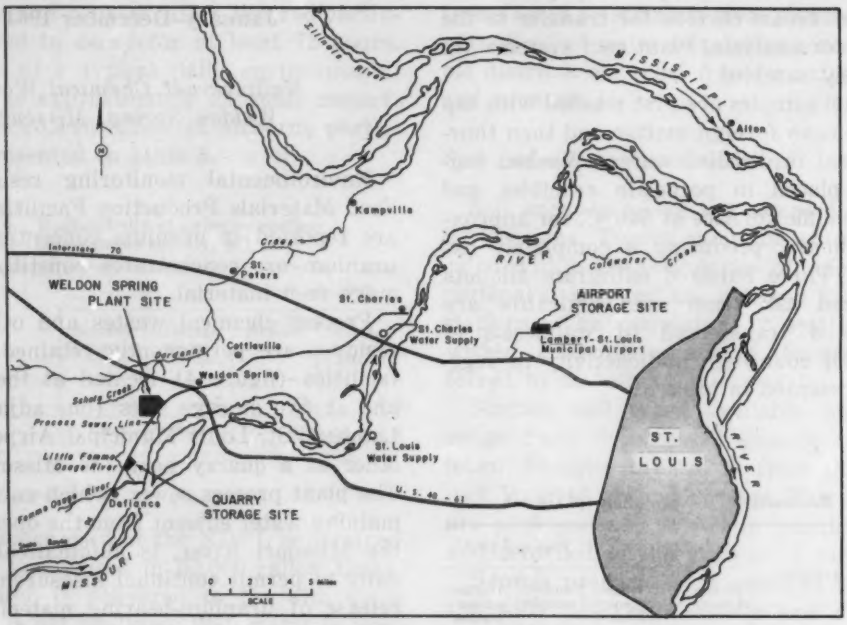


**Figure 4. Location of Feed Materials Production Facilities, Weldon Spring, Missouri**

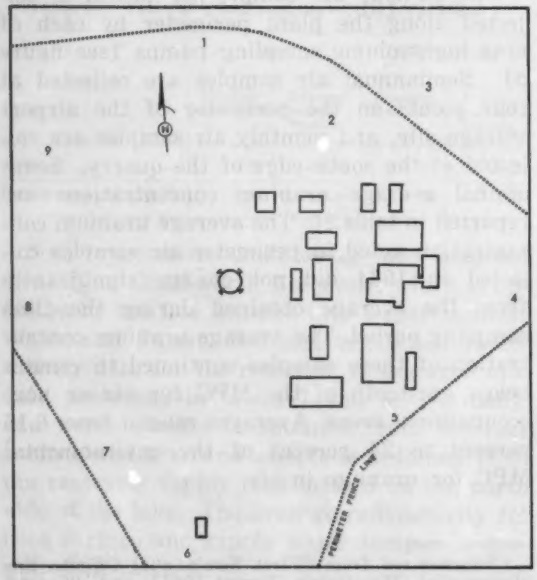


**Figure 5. Perimeter air sampling stations, Weldon Spring Plant**

**Table 10. Uranium concentrations in air, FMPF (average concentrations in pCi/m³)**

| Site | Station locations | First half 1965 | | Second half 1965 | |
|---|---|---|---|---|---|
| | | Number of samples | Uranium concentration | Number of samples | Uranium concentration |
| Plant | 1 | 4 | 0.22 | 1 | 0.27 |
| | 2 | 6 | 0.30 | 3 | 0.23 |
| | 3 | 5 | 0.20 | 3 | 0.015 |
| | 4 | 3 | 0.12 | 1 | 0.05 |
| | 5 | 6 | 0.13 | 3 | 0.02 |
| | 6 | 6 | 0.03 | 3 | 0.02 |
| | 7 | 4 | 0.08 | 1 | 0.47 |
| | 8 | 4 | 0.10 | 1 | 0.12 |
| | 9 | 3 | 0.32 | 1 | 0.15 |
| | Average | — | 0.163 | — | 0.113 |
| Quarry | South edge | 5 | 0.08 | 2 | 0.04 |
| Airport | North | 1 | 0.09 | — | NS |
| | West | 1 | 0.05 | — | NS |
| | East | 1 | 0.08 | — | NS |
| | South | 1 | 0.03 | — | NS |

NS, no sample collected

### *Water monitoring*

In addition to daily samples from the plant process sewer, monthly offsite water samples are collected from lakes and streams located within the plant's watershed, the Missouri

River, and streams near the quarry, and airport storage area site at the points indicated in table 11. Average uranium concentrations ranged from 0.01 percent to 5.2 percent of the environmental MPC. These concentrations are similar to those observed in 1963.

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| January 1959–March 1960 | *November 1960* |
| July 1960–June 1961 | *November 1961* |
| July–December 1961 | *July 1962* |
| January–June 1962 | *November 1962* |
| July 1962–December 1963 | *May 1964* |

**Table 11. Uranium concentrations in water, FMPF**

(average concentrations in pCi/liter)

| Sampling locations | First half 1964 | | Second half 1964 | |
|---|---|---|---|---|
| | Number of samples | Uranium concentration | Number of samples | Uranium concentration |
| Weldon Spring Plant Site: | | | | |
| Process sewer | 123 | 420 | 118 | 1,040 |
| Plant offsite sampling points: | | | | |
| Lake, east of plant | 2 | 4 | 2 | 3 |
| Lake, north of plant | 2 | 2 | 2 | 5 |
| Lake, west of plant | 2 | 2 | 2 | 2 |
| Lake, south of plant | 2 | 6 | 2 | 4 |
| Dardenne Creek, upstream | 2 | 3 | 2 | 3 |
| Dardenne Creek, Cottleville bridge | 2 | 4 | 2 | 4 |
| Dardenne Creek, St. Peters' bridge | 2 | 2 | 2 | 4 |
| Dardenne Creek, Kampville bridge | 2 | 2 | 2 | 3 |
| Schote Creek, upstream | 2 | 3 | 2 | 6 |
| Schote Creek, downstream | 6 | 11 | 6 | 5 |
| Plant surface drainage, west | 6 | 680 | 6 | 200 |
| Plant surface drainage, north | 6 | 170 | 6 | 200 |
| Missouri River sampling points: | | | | |
| Upstream at Defiance | 2 | 2 | 2 | 4 |
| Upstream at Femme Osage junction | 2 | 11 | 2 | 5 |
| U.S. Highway 40–61, south side | 2 | 2 | 2 | 4 |
| St. Louis city water plant intake | 2 | 2 | 2 | 4 |
| St. Charles city water plant intake | 2 | 3 | 2 | 3 |
| Quarry offsite sampling points: | | | | |
| Tributary of Little Femme Osage, ¼ mile upstream | 2 | 6 | 2 | 6 |
| Little Femme Osage, ¼ mile upstream | 2 | 2 | 2 | 3 |
| Little Femme Osage at quarry discharge culvert | 6 | 2 | 6 | 4 |
| Little Femme Osage, ¼ mile downstream | 2 | 2 | 2 | 6 |
| Little Femme Osage, 1¼ miles downstream | 2 | 6 | 2 | 6 |
| Airport offsite sampling points: | | | | |
| Cold Water Creek, southwest corner of site | 1 | 2 | 1 | 2 |
| Cold Water Creek, after site pond discharge | 1 | 4 | 1 | 200 |
| Cold Water Creek, northwest corner of site | 1 | 2 | 1 | 3 |
| Drainage ditch, north of site * | | | | |

* Ditch dry, no sample collected

## 4. National Reactor Testing Station January–June 1965 [5]

*Health and Safety Division*
*U.S. Atomic Energy Commission*
*Idaho Falls, Idaho*

The National Reactor Testing Station (NRTS) is located in a very remote area, which permits controlled releases of radioactivity from the projects with minimum hazard to sizable population groups. The NRTS surveillance program is conducted by the AEC's Idaho Operations Office. The monitoring program consists of periodic sampling of ground and surface waters, milk, and air. The locations at which these samples are taken are shown in figure 6. The results of the analysis of these samples are shown in table 12. No wheat results were reported for this period.

### *Offsite water monitoring*

Low-level liquid wastes resulting from operation of the various facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near the facilities. Although liquid wastes are monitored at

[5] Summarized from "Environmental Monitoring Report No. 16, First and Second Quarters 1965," U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.

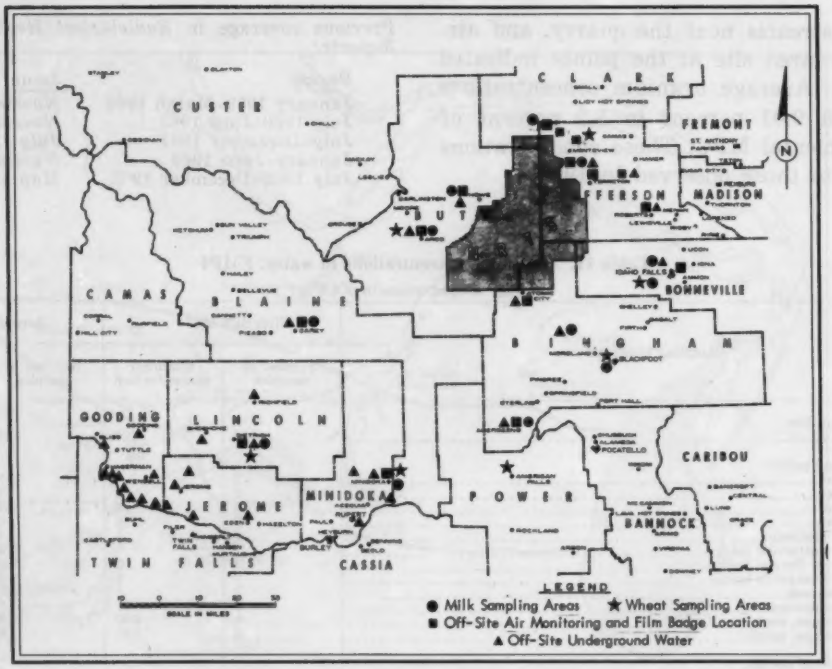


**Figure 6. Environmental monitoring stations, National Reactor Testing Station**

**Table 12. Environmental monitoring data for the National Reactor Testing Station, January–June 1965**

| Type of sample and units | Number of stations | Approximate frequency of collection | Type of analysis | Minimum level of detection | Maximum activity of single sample | Average activity per sample | Applicable concentration guides |
|---|---|---|---|---|---|---|---|
| Offsite underground water (pCi/liter) | 32 | Semiannual | Alpha<br>Beta | 3<br>6 | 4<br>20 | <4<br>9 | 100<br>100 |
| Onsite production well water (pCi/liter) | 22 | Biweekly | Alpha<br>Beta | 3<br>6 | 4<br>100 | <4<br><10 | 3,000<br>3,000 |
| Offsite air (pCi/m³) | *15 | Continuous | Beta-gamma<br>Iodine-131 | 1.6<br>3.6 | 6<br>6 | <2<br><4 | 100<br>100 |
| Offsite milk (pCi/liter) | 12 | Monthly | Iodine-131<br>Strontium-90 | 20<br>1.5 | 63<br>24 | <20<br>13 | 100<br>200 |
| Offsite area monitoring badges (mR) | *15 | Monthly | Gamma | 10 | <10 | <10 | 170/yr |

*Changed from 15 stations to 12 in April of 1965.

the NRTS before disposal, offsite underground samples are collected regularly. Most of these samples are taken from an area southwest of the NRTS since this is the prevalent direction of underground water flow. During the first half of 1965, 32 samples were collected on a semiannual basis from 32 sampling stations. The average concentrations of alpha and beta emitters were less than 4 percent and 9 percent of the applicable concentration guides. The alpha activity is attributed primarily to radioactive elements which are naturally present in the environment.

*Onsite water monitoring*

Onsite samples were taken from the plant production wells in order to monitor potable water for detection and definition of contamination. Two hundred and one samples were collected from 22 sampling stations during the

first half of 1965, most on a biweekly basis. Analyses of these samples showed that average concentrations of alpha and beta emitters were less than 0.2 percent and 0.4 percent of their respective concentration guides.

*Offsite air monitoring*

Normal operations of the present radio telemetry system calls for hourly reports by each station. These reports include information from:

Ion chamber: This instrument measures ambient radiation levels in mR/hr.

GM counter: HV–70 filter paper is cycled to a GM tube once a day. One GM tube measures the buildup of particulate activity over the day and another measures the decay of the activity collected the previous day.

Scintillation counter: Air which has previously passed through the HV–70 particulate filter then passes through a carbon cartridge. For surveillance purposes, the activity which is measured hourly is assumed to be iodine–131. This cartridge remains in place for periods up to 6 weeks.

Results of the data reported from the 15 radiation telemetry stations indicate that the sum of the average concentrations of gaseous iodine–131 and particulate activity in the atmosphere was less than 6 percent of the applicable concentration guide.

*Offsite milk monitoring*

Routine analyses of iodine–131 and strontium–90 concentrations in milk continued on a monthly basis during the first half of 1965. However, during the latter part of May, significant concentrations of iodine–131 were detected in the Idaho Falls area Grade A milk. An intensive milk sampling program was initiated during the period May 25 through June 20, 1965. The highest concentration measured during this period was 310 pCi/liter. This increase in radioactivity was attributed to fallout from the Chinese nuclear test on May 14.

Of the 72 routine analyses, only 8 samples were found to have concentrations greater than 20 pCi/liter. As indicated in table 12, the average iodine–131 levels, including the May-June samples, do not exceed 23 percent of the applicable concentration guide. Strontium–90 concentrations in the same 72 samples showed the maximum activity to be 24 pCi/liter or 12 percent of the applicable concentration guide with an average value of only 7 percent.

*Offsite area monitoring badges*

Offsite film badges were collected on a monthly basis during the first half of the year. The maximum radiation dose at a single location for any month as measured by film, was $<10$ mR of gamma radiation. The minimum detection limit for the 6 months was 60 mR of gamma, based on 6 film changes and a detection limit of 10 mR gamma on each film. For the purpose of calculating the maximum dose, each statistically zero result was assumed to be at the detection limit. The reported maximum is therefore conservatively estimated to be the upper limit of the true dose at that location. Natural background radiation levels at film badge locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100–150 mR/yr. This indicates that NRTS operations add no significant radiation to surrounding areas.

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| July–December 1960 | *May 1961* |
| January–June 1961 | *January 1962* |
| July–December 1961 | *June 1962* |
| Calendar year 1962 | *June 1963* |
| Calendar year 1963 | *September 1964* |
| January–June 1964 | *March 1965* |
| July–December 1964 | *September 1965* |

# Section V. Technical Notes

## GROSS ALPHA RADIOACTIVITY OF HUMAN BONES AND TEETH

*William E. Rothe*[1]

Bone sections from 51 cadavers, and molar teeth from 75 patients were analyzed for total alpha activity during the period from June 1964 to May 1965. The observed levels are similar to those reported by R. C. Turner *et al.*, in 1958 (*1*). However, additional data from larger samples and different age groups may be of interest to investigators concerned with the naturally occurring alpha levels in man.

### *Methods*

Rib sections were obtained from autopsy with no selection as to cause of death. Each bone was boiled in de-ionized water, scraped clean of tissue, dried, and ashed at 700°C. for 5 hours. Molar teeth extracted during routine dental procedures were cleaned of calculus and tissue, separated from any foreign material, and ashed at 900°C. Our sample preparation and analysis for total alpha activity followed closely the methods described by Oberhausen (*2*). In brief, the ashed tissues were finely ground and a 1-gram aliquot was mixed with 1 gram of silver-activated zinc sulfide and sealed in a plexiglass container. The container was then placed against a photomultiplier and the alpha-induced scintillations counted in the usual manner. This arrangement is very sensitive, and has a stable background of less than 2 counts per hour, with an average counting efficiency of 35 percent. All samples were counted for a period of 48 hours, or until a total of 1,000 counts had been recorded.

[1] Colonel Rothe is with the Veterinary Corps, U.S. Army Medical Research Unit, Europe APO New York 09180.

### *Results and discussion*

Table 1 is a listing of the total alpha activity found in the ash of rib sections obtained from human cadavers. The subjects involved were American citizens residing in Western Europe. Sex and age do not seem to be a factor in the rather wide range of activities.

Three groups of people furnished teeth for analysis. The exposure history of these people is not available. The Landstuhl group were American citizens. Those from Bad Kreuznach and Karlsruhe were Germans who had lived in these cities for the past 5 years. The alpha activities found are listed in table 2. There does not appear to be a significant difference in the group levels of total alpha activity.

**Table 1. Alpha levels in human ribs**

| Patient groups | | Activity, pCi/g ash | |
|---|---|---|---|
| Age (years) | Number | Mean ± s.d. | Range |
| 14–19 | 7 | 0.075±0.012 | 0.021–0.131 |
| 20–29 | 21 | 0.123±0.133 | 0.034–0.435 |
| 30–39 | 8 | 0.153±0.082 | 0.052–0.269 |
| 40–49 | 9 | 0.090±0.031 | 0.038–0.143 |
| 50–86 | 6 | 0.118±0.104 | 0.031–0.300 |

Table 2. Alpha levels in human molar teeth

| Source | Patient groups | | Activity, pCi/g ash | |
|---|---|---|---|---|
| | Age (years) | Number | Mean ± s.d. | Range |
| Landstuhl | 18–29 | 25 | 0.213±0.142 | 0.096–0.669 |
| | 30–39 | 6 | 0.238±0.109 | 0.121–0.376 |
| | 40–48 | 6 | 0.211±0.132 | 0.077–0.365 |
| Bad Kreuznach | 25–45 | 19 | 0.169±0.093 | 0.067–0.325 |
| Karlsruhe | 25–45 | 19 | 0.216±0.117 | 0.033–0.584 |

It is not planned to continue monitoring adult teeth for alpha activity since the levels are usually unrelated to the current exposure history of the individual. However, additional work is underway with human bone in an effort to quantitate the concentrations of normally occurring alpha emitters.

REFERENCES

(1) TURNER, R. C., *et al.* The alpha-ray activity of human tissues. Brit J Radiol 31:397 (1958).
(2) OBERHAUSEN, E. Eine szintillationsanordnung zur messung sehr geringer alphastrahlaktivitaeten. Wissenschaftliche Fragen des Zivilen Bevoelkerungsschutzes 3:1 (1959).

## REPORTED NUCLEAR DETONATIONS, FEBRUARY 1966

Two United States nuclear tests were announced by the Atomic Energy Commission during February 1966. Low yield tests (less than 20 kilotons) were conducted underground at the Commission's Nevada Test Site on February 3 and February 24.

The Commission also announced detection of seismic signals on February 13 from the Soviet nuclear testing area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate (20–200 kiloton) to intermediate (200 kilotons to 1 megaton) yield range.

## INVESTIGATIONS OF WEAPONS CARRIER ACCIDENT IN SPAIN

Following the January 17 collision of a B-52 carrying unarmed nuclear weapons with a KC-135 refueling plane, approximately 1,500 cubic yards of earth and vegetation were collected in southeastern Spain to preclude any possibility, however remote, of public health or safety hazard. There was no nuclear detonation.

The earth and vegetation contain only small quantities of radioactive material scattered when the nuclear weapons impacted. The material will be shipped to the AEC's Savannah River Plant, near Aiken, S.C., where it will be burried in the same manner as is used for disposal of other low-level radioactive waste material.

The material is being packed in 55-gallon drums. The levels of radioactivity are being carefully monitored to be sure they are well within the standard limits for such shipments.

## SYNOPSES

VARIABILITY OF FLUID MILK CONSUMPTION AND ITS RELATIONSHIP TO RADIONUCLIDE INTAKE. *J. C. Thompson, Jr.* (Cornell University). *Radiological Health Data and Reports, Vol. 7, March 1966*, pp. 139 to 144.

Using Federal milk marketing order statistics and population estimates for market areas, average monthly fluid milk consumption estimates were derived for cities located in areas covered by the Public Health Service Pasteurized Milk Network. The average per capita milk consumption for 67 cities in July 1962 was found to be 0.302 liters per day, which compared well with the Bureau of the Census estimate of 0.297 liters per day for the same month. Establishment of a comparative milk consumption-radionuclide level network is described for the 38 cities which participate in both collection of the milk order statistics and the PHS milk monitoring system. This method is useful for determining regional and temporal variations in average milk consumption. Widespread geographic variations in radionuclide intakes are apparent from a summary of data for these cities, ranging to as high as sixfold for strontium–90 and fifteenfold for cesium–137 between stations. The estimates indicate that the average intake of strontium–90 and cesium–137 are approximately 70 percent less than estimates based on an assumed milk consumption of 1 liter per day. It is emphasized, however, that the averages include portions of the population whose milk intake is considerably greater than the average. These represent the critical elements in public health planning if large releases of radioactivity should occur.

KEY WORDS: cesium–137; consumption; intake; marketing orders; milk; population; radionuclides; strontium–90.

CESIUM–137 IN FOOD—A SUMMARY OF RESULTS ON SELECTED FOODS IN THE UNITED STATES, JULY 1962 TO OCTOBER 1963. *L. R. Setter, D. Smith, and M. Spector* (Division of Radiological Health, PHS). *Radiological Health Data and Reports, Vol. 7, March 1966*, pp. 145 to 156.

Cesium–137 content and cesium–137 to potassium ratios are summarized for nine staple foods sampled during a survey conducted for six consecutive quarters from July 1962 through October 1963. Insofar as possible, the results have been grouped by the six broad geographical production regions that were previously used for comparing strontium–90 data for the same samples.

The trend of the cesium–137 to potassium ratios was similar to the stontium–90 to calcium ratios previously reported, being generally higher in fruits and vegetables than in milk; however, the lowest ratios were found in lettuce, cabbages, potatoes, and eggs. It was noted that the region-to-region variations of cesium–137 concentrations were greater than those of strontium–90 for whole milk, evaporated milk, bread, apples, and oranges.

KEY WORDS: analyses; bread; cereals, cesium–137; cesium–137/potassium ratios; foods; fruit; meat; milk; potatoes; regional concentrations; survey; vegetables.

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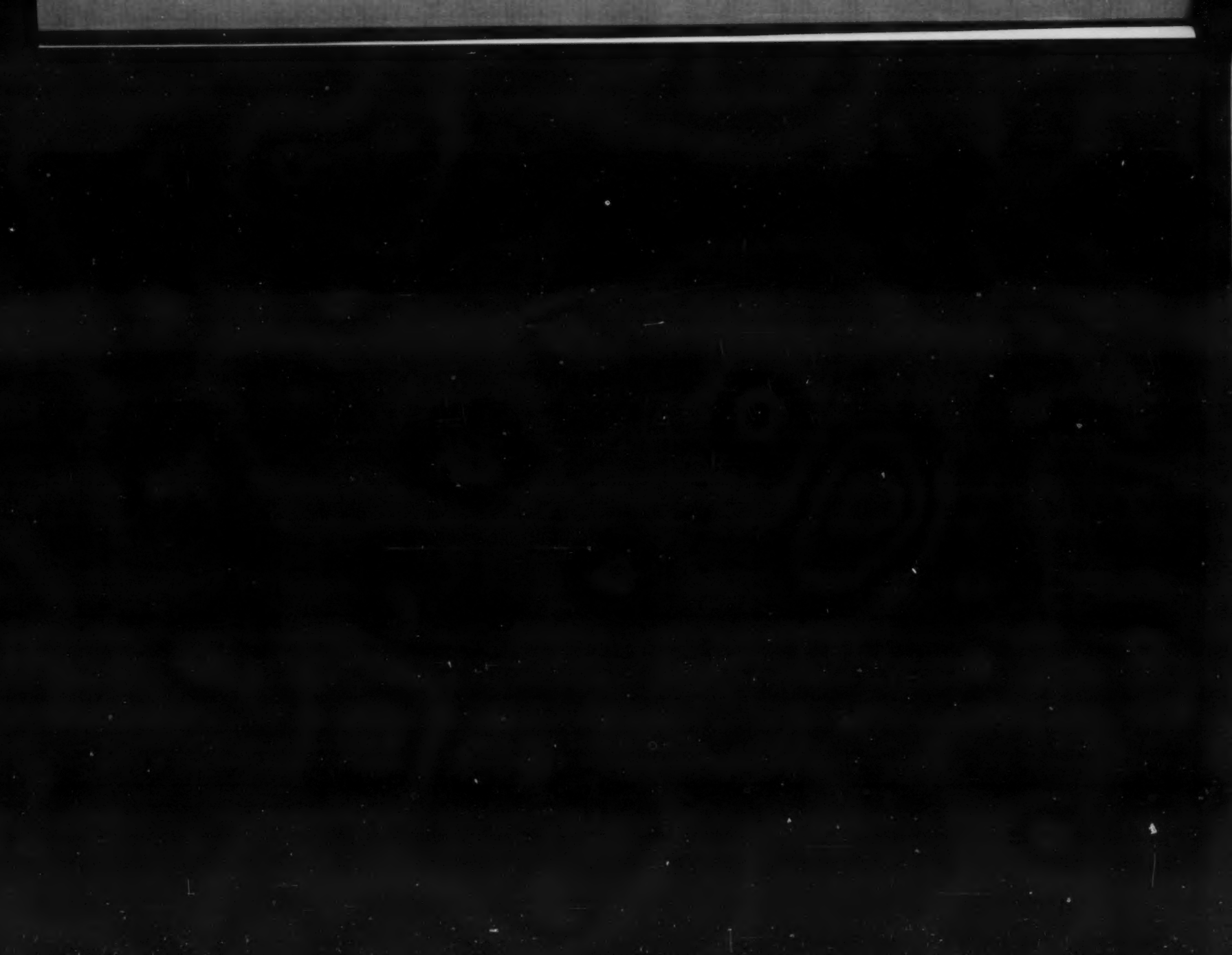

## SYMBOLS, UNITS, AND EQUIVALENTS

| Symbols | Units | Equivalents |
|---|---|---|
| BeV | billion electron volts | equals GeV |
| Ci | curie | $3.7\times10^{10}$ dps |
| cm | centimeter(s) | 0.394 inch |
| cpm | counts per minute | |
| dpm | disintegrations per minute | |
| dps | disintegrations per second | |
| eV | electron volts | $1.6\times10^{-12}$ ergs |
| g | gram(s) | |
| GeV | giga electron volts | $1.6\times10^{-3}$ ergs |
| kg | kilogram(s) | 1,000 g = 2.205 lb |
| $km^2$ | square kilometer(s) | |
| kVp | kilovolt peak | |
| $m^3$ | cubic meter(s) | |
| mA | milliampere(s) | |
| $mCi/mi^2$ | millicuries per square mile | 0.386 nCi per square meter ($mCi/km^2$) |
| MeV | million (mega) electron volts | $1.6\times10^{-6}$ ergs |
| mg | milligram(s) | |
| $mi^2$ | square mile(s) | |
| ml | milliliter(s) | |
| mm | millimeter(s) | |
| $nCi/m^2$ | nanocuries per square meter | 2.59 mCi per square mile |
| pCi | picocurie(s) | $10^{-12}$ curie = 2.22 dpm |
| R | roentgen | |
| rad | unit of absorbed radiation dose | 100 ergs per gram |

## INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

| Multiples and submultiples | Prefixes | Symbols | Pronunciations |
|---|---|---|---|
| $10^{12}$ | tera | T | tĕr' a |
| $10^{9}$ | giga | G | jĭ' ga |
| $10^{6}$ | mega | M | mĕg' a |
| $10^{3}$ | kilo | k | kĭl' o |
| $10^{2}$ | hecto | h | hĕk' to |
| 10 | deka | da | dĕk' a |
| $10^{-1}$ | deci | d | dĕs' i |
| $10^{-2}$ | centi | c | sĕn' ti |
| $10^{-3}$ | milli | m | mĭl' i |
| $10^{-6}$ | micro | μ | mi' kro |
| $10^{-9}$ | nano | n | năn' o |
| $10^{-12}$ | pico | p | pē' co |
| $10^{-15}$ | femto | f | fĕm' to |

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